THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

THE INSTITUTION OF

PRODUCTION ENGINEERS JOURNAL

10 CHESTERFIELD STREET . LONDON . W1 Telephone : GROsvenor 5254/9

Vol. 34, No. 7 *Price 10/-* *July 1955*

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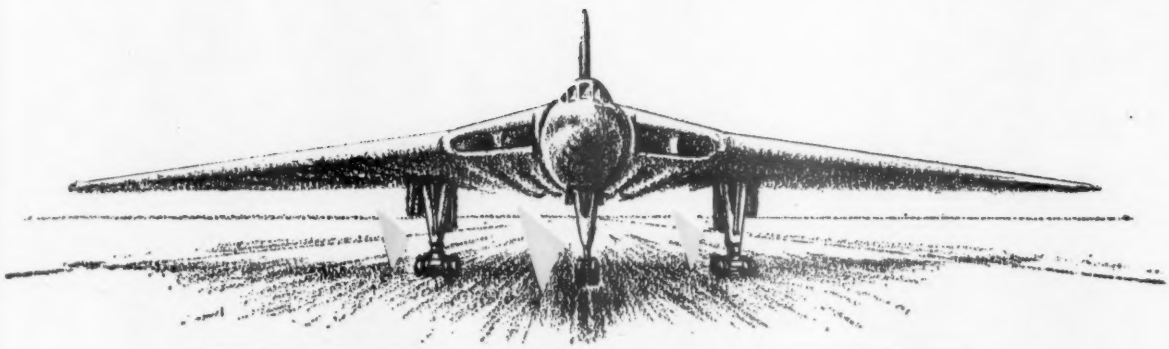

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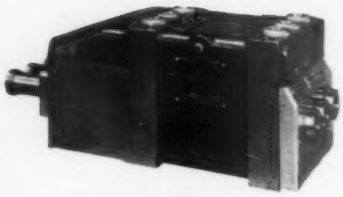

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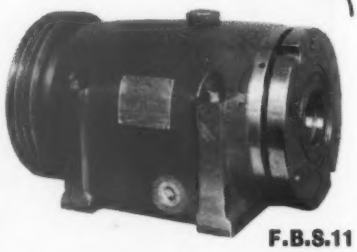

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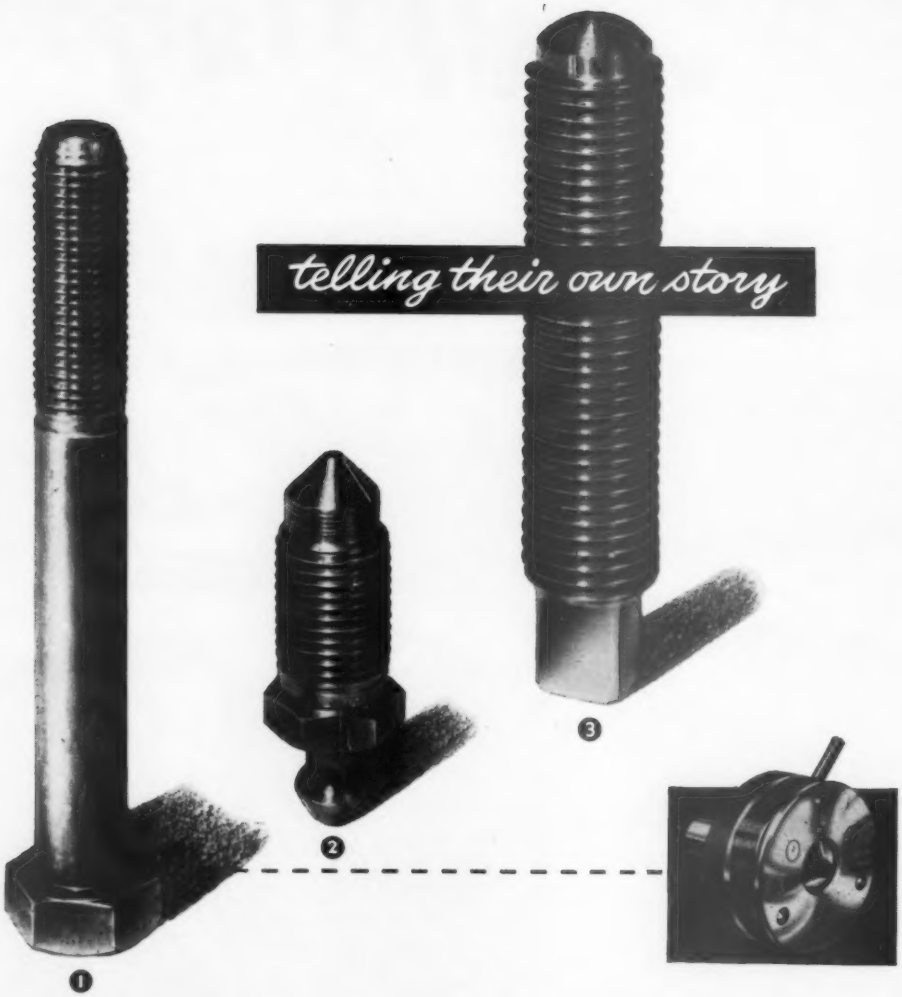

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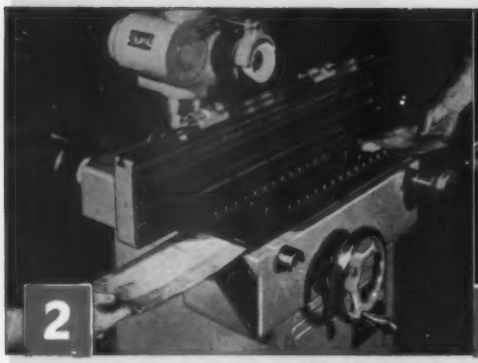

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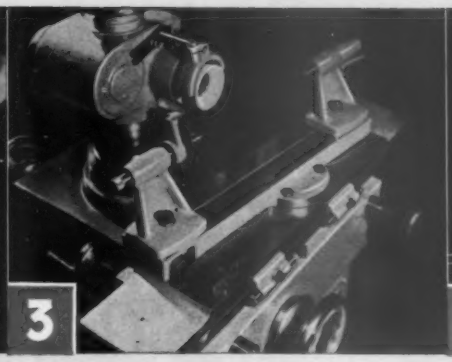

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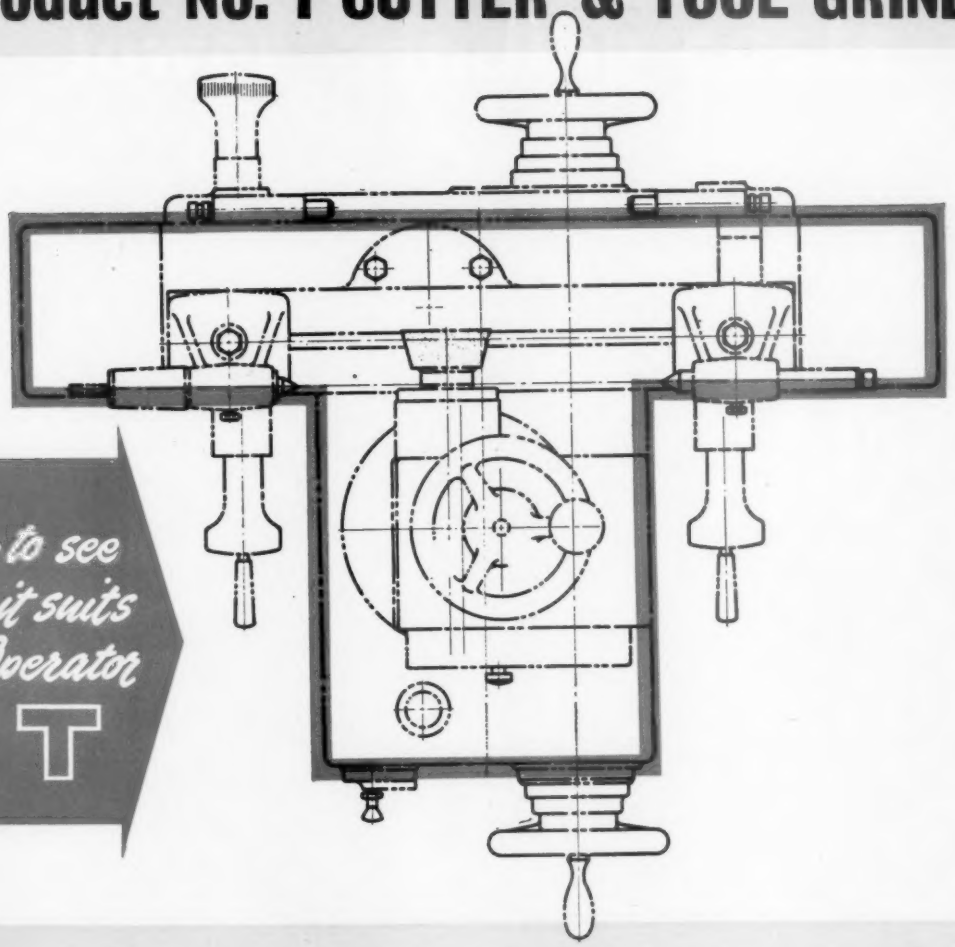

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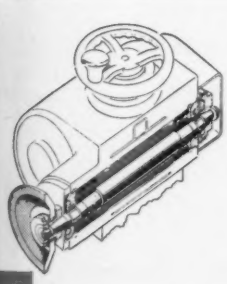

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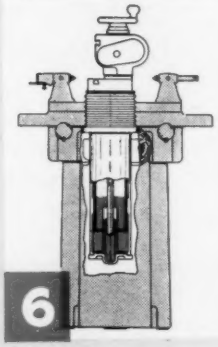

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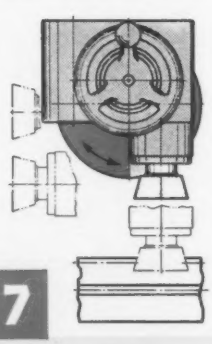
Wheelhead pile (sealed against grit) is easily adjusted to correct height, by handwheel at top of wheelhead unit.



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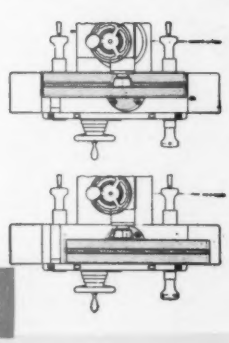
Eccentric 360° wheelhead swivel increases cross range of wheelhead.



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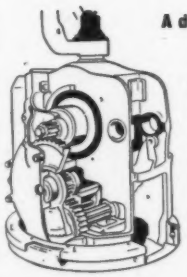

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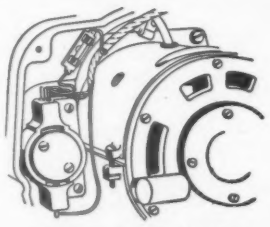

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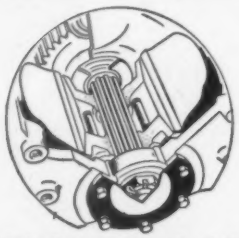

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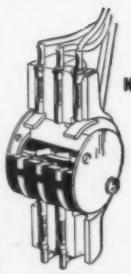

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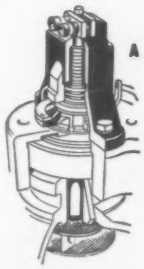

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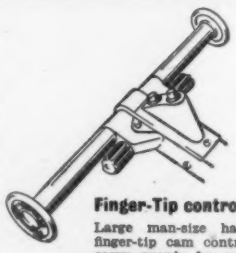

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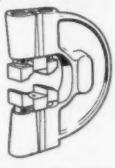

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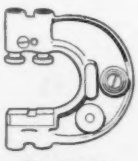

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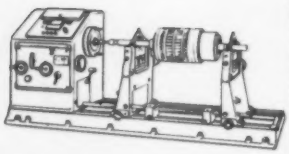

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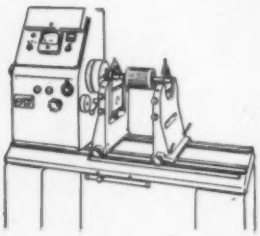

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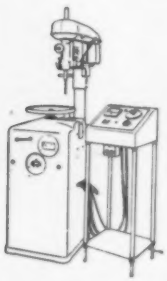

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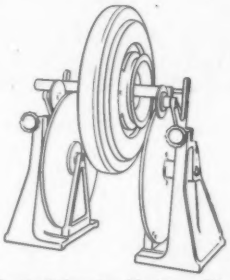

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President of the Institution

1955/56

From the portrait by Maurice Codner

The Institution of Production Engineers Journal
VOL. 34 NO. 7 JULY, 1955

The Margate Conference

THE Papers presented at the Institution's Conference on "The Automatic Factory—What Does It Mean?", held at Margate from 16th/19th June, will be published in this and subsequent issues of the Journal. There will also be available shortly a separate bound publication of the proceedings, including the opening and closing addresses, the Discussion Group Reports, and a review of the display of equipment. Members of the Conference will receive a copy of this report free of charge; otherwise the cost per copy will be 25/- post free. An order form appears in the Supplement to this Journal.

This issue of the Journal contains Sir Walter Puckey's address at the First Plenary Session, and the first selection of Discussion Papers.

THE AUTOMATIC FACTORY— DREAM OR NIGHTMARE?

by SIR WALTER PUCKEY,

President of the Institution.

IN December of last year, Orwell's "1984" caused controversy and some consternation among many television viewers who realised what may happen to us thirty years from now. The purpose of this Conference is to show a more limited audience what the industrial scene might well be like in 1984 and, I hope, to help it in shaping course today so that 1984 will bring, not the world of Big Brother and the enslavement of the spirit, but one where man will have achieved greater moral and material advancement, and exercised greater power over insecurity, drudgery and inefficiency. In practical terms, where he will have achieved Mr. Butler's recent target of a doubled standard of living.

How much will Automation, or the Automatic Factory, contribute to these objectives? Are we on the eve of a second Industrial Revolution? These questions will confront us many times during the next few days, and in order to provide a basis for discussion let me attempt a few definitions.

Automation (1) was first widely publicised by Diebold (2), who gave creative credit to Harder (3). Diebold quotes Harder's use of it to describe "the automatic handling of materials and parts in and out of machines" (4). This has the merit of simplicity; I wish I could say the same for other and later definitions.

By extrapolation, the Automatic Factory is one where automation is universally applied — where everything within is handled automatically. Elementary thought tells us that no such Automatic Factory exists, as even the master button must have its human controller, although he may sit in an office 100 miles away. In practice some machines and departments are today described as 'automatic' which still require people to control them, performing such functions as feeding, inspection, maintenance, and very important indeed, disposing of the completed product, whether it be statistics, or sports cars.

We conclude, therefore, that it is the trend towards fuller automation in which we should be interested, and that the very term 'Automatic Factory', attractive though it might sound to many, is a misnomer, is misleading and is, indeed, dangerous.

Are we on the eve of a second Industrial Revolution? Before deciding let us look back into history. The word 'revolutionary' is often applied today, but compared with the total impact of the first Industrial Revolution the examples are very restricted in effect. Yet any one particular discovery may well, in the course of time, be regarded by the historian as he today regards Watt's engine, the starting point of a long-term widely applied revolution, and from a number of current examples the development of the jet engine by Whittle may be quoted. In a matter of only 15 years, the majority of front line military aircraft of the world have become powered by an entirely new form of unit; truly, a revolutionary step.

Or consider the main line railroads of U.S.A. In 1947 they had 37,100 steam locomotives and 4,400 diesel electric units. Yet only six years later the numbers were 11,700 steam locos and 22,700 diesel-electrics. What a revolutionary target for British Railways!

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(1) The word itself has a somewhat mixed parentage. It is derived from the Greek automatos — self moving; AUTOS, self and the stem MAT, moving. To this is added the Latin suffix ION, being or state of being. See I.Prod.E. Journal, February, 1955.

(2) "Automation — The Advent of the Automatic Factory" — by John Diebold.

(3) D. S. Harder, Vice-President for Manufacturing, Ford Motor Co., U.S.A.

(4) Harder has more recently defined it as "the automatic handling of parts between progressive production processes".

The First Industrial Revolution

The first Industrial Revolution had a profound effect upon Britain and the world, but many other great movements are encompassed in our historical scene. Industry has, of course, existed for many centuries, but however much Rome and Greece, for instance, conditioned our modern lives, I must go back only as far as the period which immediately preceded and conditioned the Industrial Revolution, i.e., the 16th and 17th centuries.

Many individual steps are grouped by the historian to describe a significant trend and identify a period in history. It is likely to contain widespread social and industrial movements taking place over many decades. Using such a basis we might agree that Hall (5) uses it accurately to describe a period which, spread over two or more centuries provided the scientific foundation on which the first Industrial Revolution was built. "Much more" he says, "has been learnt about Nature, from the structure of matter to the physiology of man, in the last century and a half (6) than in all preceding time".

As Pope said :

"Nature and Nature's laws lay hid by night,
God said 'Let Newton be', and all was light!"

But within the time period described by Hall, another revolution was taking shape in which the leading rôles were taken by capital and commerce. Britain's overseas trade was her principal source of capital investment and gain, and her great success in this activity provided the wealth for subsequent industrial expansion. Among other opportunities the opening of the Atlantic routes gave a new character to commerce, not only by the greater tonnage shipped but because of the more popular cargoes carried; tea, sugar and tobacco were in greater demand than the pepper and spices of an earlier age.

It is impossible to declare whether large scale demand for a product precedes or follows production, but there is no doubt that the two are intimately connected and no consideration of production or productivity must lose sight of this basic fact. The large-scale use of capital to promote both commercial demand *and* production resources has been an essential feature of Britain's progress over the last few centuries. "'Two centuries ago not one person in a thousand wore stockings; one century ago not one person in five hundred wore them; now not one person in a thousand is without them'. This quotation (7) illustrates a feature of the Industrial Revolution that made a profound impression on the imagination of the time. When capital was applied to production on a large scale, it gained its profits by producing in bulk; producing, that is, for mass consumption. Energy and brains were now devoted to satisfying, not the luxurious taste of the classes served by the commerce of mediaeval Europe, but the needs of the poor consumer" (8).

So, therefore, the stage was set for large-scale *industrial* expansion, and into this favourable atmosphere the steam engine was introduced, an invention with wider possibilities than almost any previous discovery. One day in the spring of 1765, James Watt, instrument maker, 29 years old, was walking on Glasgow Green, and it being Sunday he probably turned his thoughts from a contemplation of Heaven and Hell to a current practical dilemma — how could a cylinder be both hot and cold at the same time. And so was formed the idea of a separate condenser, and with it the possibility of employing steam as a motive power for machines. Eleven years later his first successful engine was made, and within another twenty years his engines "were in use in mines and foundries, in textile and paper mills, and great columns of smoke from innumerable chimneys spoiling the light and colour of the skies declared the triumph of industry and the glory of man".

As a Cornishman I take both pleasure and pain in recording that it was among the enterprising Cornish mine-owners that he found his earliest customers, who he once described as having "the most ungracious manners of any people I have ever yet been amongst".

Watt, like many inventors, was not a skilful business man, and it was Boulton who realised more vividly the potentialities of this new power unit; he was all for haste as "the people in London, Manchester and Birmingham are steam-mill mad". Today, for steam-mill read "Electronics"!

The realisation that rotary power could be provided by Watt's engines really revolutionised British industry. Many factories required water power to provide rotary motion, and this placed great limitations on their size, location and scope. In 1785 the first cotton mill, at Papplewick, was powered by a steam engine, and "between 1775 and 1800 Boulton and Watt erected 289 steam engines in England. The first revolution, the revolution in the textile industries, was immensely accelerated but not caused by Watt's invention. Until that invention mills had to be placed by the side of streams, and most of the machinery was made of wood with metal fittings. Watt made it possible to set up mills anywhere, and, as engineering developed from his discovery of rotary motion, it was easy to provide metal machinery. Such machinery came into general use between 1825 and 1840. Moreover, the application of steam power to spinning and weaving was followed, of course, by an immense expansion of the textile industries. The second revolution, that of transport, and the third, the use of machines for making machines, depended entirely on his invention. If one man in the history of the world is to be taken as the author of modern civilisation, it is this melancholy mechanic, in whose outlook on life the superstitious might perhaps discern a warning of its ambiguous blessings" (9).

It is interesting here to recall Boulton's great influence during this formative period. Not only had he the business initiative that Watt lacked, but he was in many ways a pioneer in industrial management. At his Soho works he practised management

(5) "The Scientific Revolution 1500-1800" by A. R. Hall.
(6) He refers to the period between 1800 and 1950.
(7) "The Results of Machinery (1831)" — a publication of the Society for the Diffusion of Useful Knowledge.
(8) "The Rise of Modern Industry" by J. L. & Barbara Hammond — page 210.

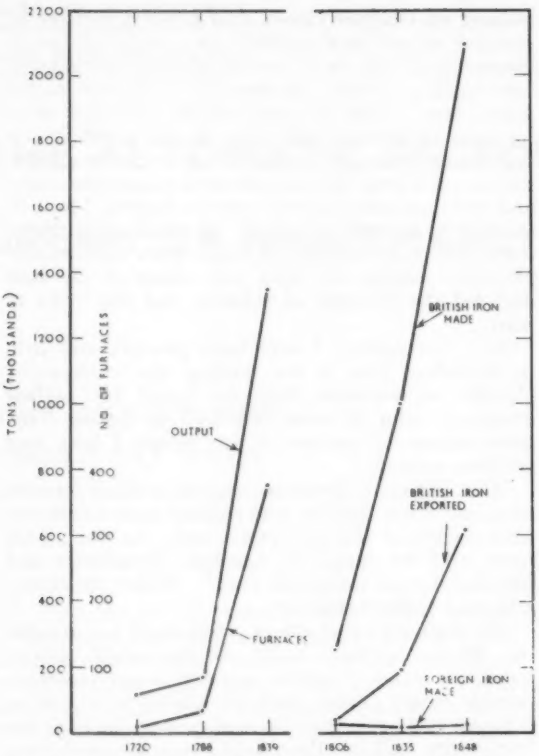

Fig. 1. Production of pig iron in Great Britain.

in an astoundingly scientific way for his age, and as the description runs: "While sitting in the midst of his factory surrounded by the clang of hammers and the noise of engines, he could usually detect when any stoppage occurred, or when the machinery was going too fast or too slow, and issue his orders accordingly" (10). One can well imagine him today taking full advantage of the modern control systems which are an essential part of automation.

As so often happens, progress in one direction inevitably led to progress in many others; the pebble created many ripples. Watt's invention was the catalystic force which promoted energetic discoveries over a wide field, and "the patents issued in the quarter of a century following 1760 were more numerous than in the previous century and a half" (11). Bell, in 1812, applied the power of steam to navigation, thus heralding a new age of transport. The manufacture of productive machine tools was stimulated by the higher accuracies and better finishes demanded by the new engines. The discoveries, particularly of Cort, that the iron industry need not rely upon charcoal, were of great importance to every industry. "Fifteen tons of bar-iron could now be produced in the time formerly required for producing a single ton, and, moreover, this could be produced by the use of coal in place of charcoal" (12).

Fig. 1 shows clearly the expansion of British iron works over this period — truly a revolution.

The pottery industry is interesting as a study in delayed technical progress. Increasing trade brought a demand for better internal communications (how history is repeating itself today), and through the efforts of men like Josiah Wedgwood, the Potteries, among other areas, were opened up to the outside world, this alone resulting in a great increase in trade. Oddly enough, increased mechanical power played little part in this increased business, and "up to the year 1845 the potting industry had remained almost completely unaffected by the scientific and mechanical improvements which had greatly modified some trades, and had revolutionised others. The whole range of mechanical science was almost solely represented in the manufacture of potting by the throwers' wheel — identical in mechanical principle, and practically so in form, with that used by the ancient Egyptians — and the turners' lathe" (13).

Josiah Wedgwood, writing in 1783, said this about the effect of changing conditions among the workers, "the inhabitants bore all the marks of poverty to a much greater degree than they do now. Their houses were miserable huts; the lands poorly cultivated, and yielded little of value for the food of man or beast, and these disadvantages, with roads almost impassable, might be said to have cut off our part of the country from the rest of the world, besides rendering it not very comfortable to ourselves. Compare this picture, which I know to be a true one, with the present state of the same country. The workmen earning near double their former wages — their houses mostly new and comfortable, and the lands, roads, and every other circumstance bearing evident marks of the most pleasing and rapid improvements".

Such was the view of one pioneer on the effects of better business among those who worked to provide it.

It was in cotton where the Industrial Revolution made its greatest impact. In a few years the cotton industry reoriented itself from East to West, and we became clothed with cotton goods. In 1785 Watt's steam power began to replace water power, and textile production removed from villages and cottages into the large factories. What was done under many roofs was now done in large factories. "In 1813 there were 2,400 power-looms in Britain; in 1820, 14,150; in 1829, 55,000; and in 1833, 100,000. The inventions changed not merely the power but the character of the industry. Before the Industrial Revolution, spinning and weaving were both cottage industries. This revolution in the methods of the industry caused, of course, an immense increase in its productive capacity; in 1764 England imported less than 4,000,000 pounds of cotton wool, in 1833 more than 300,000,000. The price of the raw material in 1833 was less than one-fourth of its price in 1798"(14).

(9) "The Rise of Modern Industry" by J. L. & Barbara Hammond.
(10) "Lives of the Engineers" by Samuel Smiles.
(11) "Great Britain from Adam Smith to the Present Day" by C. R. Fry.
(12) "The Rise of Modern Industry" by J. L. & Barbara Hammond — page 140.
(13) "The Staffordshire Potter" by H. Owen.

Man in the First Industrial Revolution

But what about the relationship between man and man in this period of Industrial Revolution? In many ways men had been released from bondage, from narrow village life to larger and rapidly changing communities, where, it could be argued, they would find position and wealth undreamt of in a previous life. In the peasant village initiative was checked by custom, capital investment by community restrictions; the new industrial possibilities opened up to those with capital an entirely new world, but to that majority of people without capital it meant embarking on a new way of life in which new forms and opportunities of employment were neutralised by a greater insecurity, which increased a natural reluctance to change the old and tried for the new and unknown.

The Industrial Revolution widened the gap between rich and poor, between novelty and custom, and between town and country, and the closing of these gaps has preoccupied us during much of the subsequent 100 or more years.

It is easy to condemn the excesses of those early years. We were temporarily knocked off balance by a tide of scientific and technological progress the like of which had never before been seen. Custom, tradition and religion, which had once been great stabilising forces, were largely swept aside in the flood. Now large numbers moved forward from a stabilised society to a new system of production where "private gain was accounted as public good".

Let us move on through the Victorian and Edwardian eras to the last few decades. Men of my generation who have achieved managerial rank will have seen many residual stresses left by those who helped to forge Britain's industrial greatness. The romance and achievements are soon forgotten, while a memory of the errors and excesses remain for generations as warning and a guide to those who, in a later age, are confronted by similar forces and similar possibilities of change. We have moved into such an age, and this Conference is designed not only to demonstrate some of the new discoveries, but to look at the past and present as a help in dissolving the mists that surround 1984, so that we not only see our goal but plan more wisely to achieve it.

The Results of the First Industrial Revolution

How far have we corrected the excesses of the first Industrial Revolution? I said earlier that this period widened the gap between rich and poor, novelty and custom, and between town and country. Let us examine what has happened since.

"Action provokes reaction", and as a direct result of the widened gap between rich and poor great industrial and social movements such as Trades Unions and the Labour Party arose. These, together with a generally increased social conscience, reversed the trend and reduced the gap. Today the equalisation of income and opportunity has reached a stage undreamed of 100 years ago; indeed, the pendulum has swung so far that by 1984 it may well have reversed again, because of a growing recognition that "Some men are more equal than others", and that given suitable *minimum* remuneration, man's reward should be more commensurate with his skills. It was, I believe, Chesterton who said "the British worker is more interested in the inequality of horses than the equality of man". Without prejudicing the first we have moved almost too much towards the second, and the trend of Automation may force us to grant more encouragement to skill, because we shall demand so much more of it.

What about the gap between novelty and custom, the clash between those who want change and those who don't? I believe it has decreased considerably, and men are today conditioned more to accept change, although too many restrictive practices still remain in all grades and industries, among managers and workers alike. Naturally, most of us are conditioned by the past, which casts its shadow over today and tomorrow, and the removal of this shadow is an important thing to achieve if we are to reach 1984 in triumph. It will be achieved by educating more people to accept the advantages of an increasing rate of change, by getting them to discard old customs and precedents, having been convinced that less of this protective clothing will be wanted in the more favourable climate of the future.

But we don't throw away an overcoat unless we are satisfied that the barometer is 'set fair' for a long period ahead, and our British climate is notoriously fickle. There is, too, a real danger that if we throw away too much 'custom' we throw away stability, and far from wanting less of this commodity in 1984, we want more. How then can we ensure greater personal, family and national security in a rapidly changing technological world? To this question there is no single answer, but the need to provide satisfactory ones is as great today as at any time in our industrial history.

What about our third gap — between town and country? The steam engine harnessed to rotary power created the modern factory, and its ugly setting, the industrial town. The "dark satanic mills" are going, but many blots still remain on Britain's landscape, showing evidence of excesses which, because of size, location and durability remain to this day. But, as is often the case, invention counteracts invention, and two devices, the electric motor and the internal combustion engine, have done much to narrow the gap and restore a better balance.

The electric motor made possible a new approach to factory layout and life. Why, even in my time, the progress from a jungle of belts to the modern, decentralised factory has been amazing. Production engineers have been able to set up small plants in country areas, almost eliminate 'depressed areas', improve working conditions immensely, develop layouts and machines greatly, and increase flexibility. We have, too, commenced an almost revolutionary mechanisation of the home itself, encouraged by better conditions of factory life and the consequent shortage of domestic labour.

The internal combustion motor speeded up immensely the large-scale movement of men and

(14) "The Rise of Modern Industry" by J. L. & Barbara Hammond — pages 183 - 184.

materials made necessary by mass production and consumption. It mechanised the roads and air, leaving the steam locomotives of Trevithick and Stevenson to puff along behind, thus once again showing, as in Lancashire today, that to lead a revolution is not good enough. Leadership involves 'eternal vigilance'.

The Legacy of the First Industrial Revolution

What remains of "the tumult and the shouting"? Fortunately many earlier excesses have been corrected, even if by *force majeure*. Unfortunately, many of its good features have lost impetus over the years, and Britain has in turn lost her place as the workshop of the world; others have continued our own pioneering efforts, although many signs indicate that we are more vigorously throwing aside much of our prewar inertia. We can't afford not to!

In the technological sense we have, I think, retained much of our early success in initiating what Lord Halsbury calls 'novelty', and we are proud that many important scientific milestones have been erected by the British. Our atmosphere favours scientific activities, and industry and government support them well. It is in the *development* and *production* of novelty where we have relatively lost ground, and where we require reinforcements. Fortunately these are becoming available, in many forms. The Institution of Production Engineers is a modern child, born of necessity. Other professional bodies are becoming more interested in the technique of development and production of materials, machines, managers and men. Technical colleges are increasingly concerned with the education of more who can absorb scientific knowledge and translate it into better goods. Even our Universities, sometimes reluctantly, are realising that they must play a greater rôle, of which a significant part is to understand more clearly what is meant by 'industry' and what help it wants. Oddly enough, the very strength of our scientific effort has created its own bottleneck, but many signs indicate that the 'flow' is now increasing, although nowhere near what it should be.

In the study of man and his working environment we have, I believe, progressed greatly, largely in the last few decades, and never before have so many managers and men understood the place of man in industry and in his social structure, the need for closer mutual understanding, and the necessity to formalise and improve this through joint consultation, education, training and promotion. In this respect we are in better shape to face the second Industrial Revolution because, unlike the 19th century, we are now moving from one system to a similar one, albeit at a more rapid rate. It is, therefore, more a matter of speeding up the existing machinery(15) than of replacing the old entirely with new.

The Second Industrial Revolution

Are we then on the eve of a Second Industrial Revolution? My answer is that the First Industrial Revolution, apart from some pockets of resistance, petered out in the first few decades of this century, having lasted for about 150 years. The Second Revolution, overlapping its predecessor as all movements do, is already under way, and differs from the first in a manner that is easily explained, but profound in nature. If the first Industrial Revolution is represented by the discovery of *machine power*, the second Industrial Revolution can be represented by *the discovery of man's power helped by machine*. The second Revolution—we might call it "the Industrial Renaissance"—started when a significant number of people realised that in developing the machine age we had forgotten man; the next few decades will, in my view, be devoted to greater means of uplifting man's own power by (a) augmenting his brawn power through mechanisation, (b) augmenting his brain-power through more control power and (c) controlling his emotion power by better managerial power.

(15) I use the word 'machinery' in the widest sense.

PHASES OF THE FIRST AND SECOND INDUSTRIAL REVOLUTION

Pre 1st. Industrial Revolution — Hand power

1st. Industrial Revolution — Hand power + Machine power

2nd. Industrial Revolution (early period) — Machine power + man's power.

2nd. Industrial Revolution (later period, say 1984) — Machine power + man's power + control power.

Figure 2.

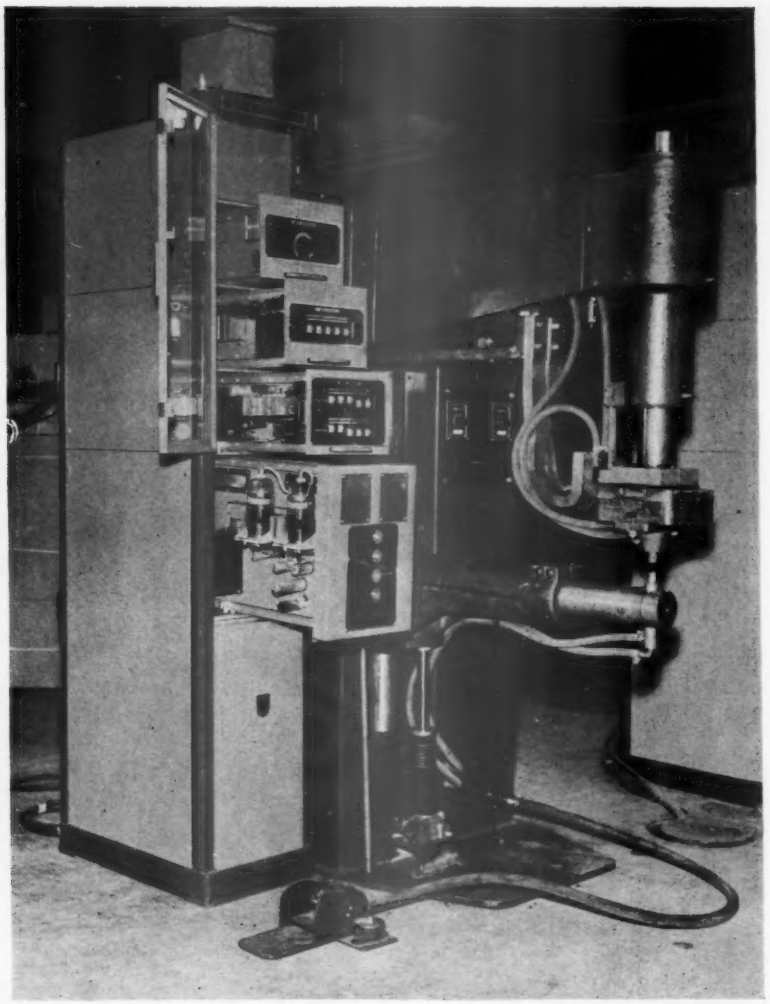

Fig. 3.

(Courtesy of Philips Electrical Ltd.)

Greater control power will help him to decide, relieve him of routine, of boring, dangerous tasks and enable him to do existing things better and new things well. It may, in due course, provide him with greater leisure to escape into the troubles of leisure, but by 1984 I do not anticipate a great reduction in the working week (16), merely a more effective use of hours.

Let us attempt in Fig. 2 to state these significant trends in a simple (almost too simple) form.

Control Power

'Control' has many alternative definitions, including check — restrain — govern — regulate — command — compare. It is, I believe, the most important single word in the Vocabulary of Automation and it is probable that it will be exercised more through the one word 'Electronics' than any other.

Last November we remembered the 50th anniversary of Sir Alexander Fleming's discovery of the thermionic valve, and today we see around us the wide possibilities of electronic power. The radio industry had by 1939 brought it into millions of homes, but war stimulated great developments, particularly in radar, which helped to win the Battle of Britain and has revolutionised land, sea and air tactics ever since. Electronics has arrived in a big way; it provides us, not with bulk power, but more precise means of controlling and utilising bulk power, and it is obvious that more horse power *per capita* requires relatively more control of that power. The small machine tool may be powered by a fractional H.P. motor switched straight on and off the line, but its larger, more complicated successor needs control equipment of a bulky and expensive nature, such as Fig. 3 and 4. A machine tool electronically controlled, or linked to others by transfer mechanisms, as described by Stokes, Williamson and Bezier, needs an even larger percentage of control equipment.

(16) See page 414.

Fig. 4.
(Courtesy of Philips Electrical Ltd.)

Will the advantage of better control more than compensate us for the greater cost and complication of the controls themselves? The answer, as often, is that "it all depends", and the wise manager will request as good an individual case to be made for greater *control power*, as he normally requires for greater mechanisation.

The decision may, however, become more difficult, as he is entering a period where his company's future must depend increasingly upon an appreciation of research trends over a wide field. Man's imagination must leap over company and industry-wide barriers into other spheres, and he must realise that, as the international volume of research increases so the rate of change within his, or his competitor's, business may be forced to increase considerably. Cross-fertilisation becomes a factor of much greater importance.

Let us consider the volume of research. We have, in recent years, invented invention, and the puny resources of Boulton and Watt look small beer compared with the organised flow of research, development and patents emerging from government and industrial back rooms. In Watt's time the communication of ideas from one sphere to another took time; now what was yesterday's invention becomes today's knowledge, creating its own urge for development, and unsettling customers who, when they hear constantly of new things cannot be blamed for wanting them quickly. Automation is a typical and topical case, where wide knowledge of its possibilities is spreading rapidly among men, creating a demand for new techniques and equipment which is unlikely to be satisfied in volume for years to come. It is a paradox that while knowledge of what is possible has speeded up, delivery of the goods takes considerably longer.

History shows that great movements start from isolated discoveries or individuals, and I have quoted the steam engine and electric motor as examples; at least they represented the visible tips which, as with an iceberg, are thrown up by a great volume of

WHAT CONSTITUTES A HIGHER STANDARD OF LIVING

(1) More commodities in the shops.

(2) A higher "real" income (a 20/- pound).

(3) A reduction in taxation.

(4) A reduction in working hours.

(5) Better and cheaper education.

(6) Retirement benefits themselves doubled to provide a more reasonable relationship to previous earning standards.

(7) Fuller opportunities to develop personal aptitudes, take wider responsibilities and contribute as a member of the working team.

Figure 5.

discovery and development beneath the surface. Two gleaming new tips have thrust themselves into view in recent years, popularly named Electronics and Nuclear Energy. These two are the great 20th century technological forces which, like all large forces, may either help to wreck mankind or, as is equally possible, provide us with new tools for the arts of peace.

The Frame-Work of Automation

Before dealing with the tools of Automation we should, I think, discuss certain leading questions which extend far beyond automation, and which concern themselves with the national frame-work in which our activities are contained.

What, for instance, is the *purpose* of automation ? According to some people it is to displace labour, but this is a negative view. If it is to fulfil a social need, what is this need ? I am not capable of writing a dissertation on human happiness, and other speakers such as Professor Williams and Mr. F. G. Woollard will deal with moral and human values more competently. I must be content with a more mundane and more commonly understood social aim — the target which Mr. Butler laid before us recently — a doubling of our standard of living in the next 25 years. One might assume from the recent judgment given by the nation that the last budget was a step towards the realisation of that target.

What constitutes a higher standard of living ? The answer must be a personal one, but an enquiry among a number of people has shown that many individual answers may be condensed into a few, and these are shown in Fig. 5.

It was refreshing to find that the majority of those asked realised fully that these amenities will be provided only by higher personal and national productivity, which in the long run must pay for increased rewards.

To analyse all of these requirements would take us outside the scope of this Conference, but I felt that it was possible to condense again and to leave before us just three essential things that could be regarded as the industrial framework within which automation could be studied. They are shown in Fig. 6 and I shall comment briefly upon each.

(1) *A Greater Ability to Translate New Ideas into Practical Reality*

I have already mentioned the increasing scale of research, which may well provide more dissatisfactions if we fail to translate the increasing amount of novelty more quickly into practice. This is a real challenge to our ingenuity in many directions, ranging from a better understanding between researchers and producers to the provision of better production control systems for taking care of the greater amount of sub-contracting necessary in this specialist age.

It is a problem of particular interest to industry, but it has, too, a considerable social significance, as a greater ability to develop the increasing number of new discoveries, and produce them quickly, will, of all things be the one most likely to maintain our competitive power. We will be successful abroad in strict relationship to our ability to design, make and export Novelty.

(2) *A Greater Recognition of the Value of Human Rights, Responsibilities and Aspirations*

Here we are in much better shape to face the future than in the 18th century, and I am convinced that the more general acceptance of man's important place in a modern industry and society started the second Industrial Revolution. Much important research is today helping us towards this greater understanding of man and the work of such men as Wiener (17) and Grey Walter (18) who I had the pleasure of meeting recently, is likely to extend the

(17) "The Human Use of Human Beings" by Dr. Norbert Wiener.

THE TASK OF INDUSTRY

(1) A greater ability to translate new ideas into practical reality.

(2) A greater recognition of the value of human rights, responsibilities and aspirations.

(3) An increase in individual and national productivity to an extent which while providing not only a higher real income for those at work, will also provide increasing support for those being educated and those in retirement.

Figure 6.

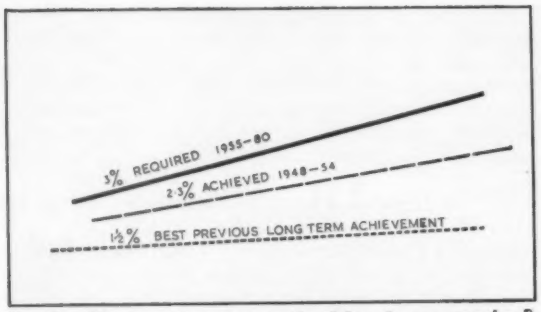

Fig. 7. How much extra productivity do we require ?

frontier of knowledge in this field. I recommend all production engineers to study the "human use of human beings".

Electronic development will help greatly in these researches, first by providing tools for the researchers and secondly, by off-loading on to the electronic brain in its various manifestations, routine work previously occupying and perhaps wasting that precious thing, the human brain. We must, however, keep one foot firmly on the ground, as production engineers know from experience that the abilities and possibilities of individual men can never wholly be specified in a laboratory. But many men share common interests, and one feels sometimes that we should emphasise our similarities rather than our differences. It is because of this that I believe more help can be given to so-called practical men by the scientists, never forgetting, however, that it is not only the law applied to the many, but its application to individuals that requires skill. Used together they can be unbeatable.

(3) *An Increase in Individual and National Productivity, Providing a Higher Real Income for those at work, and Increasing Support for those being Educated and those in Retirement*

The economists may well say that this is the nub of the argument, and that all other activities are useless unless we are able to produce more or less. Partly true although, like profits, there is no virtue in higher productivity alone; it is what one does with it that matters. At least three important questions arise in considering (3) :-

(a) how much increased productivity we require to achieve the target;
(b) what is the national attitude towards increasing productivity ? ;
(c) what are the basic power requirements ? ;

Let us consider each in turn :-

(a) *How much Increased Productivity we Require to Achieve the Target*

Fig. 7 is an attempt to provide an answer and I am grateful to P.E.P. (19) for the statistics on which this graph is prepared.

It shows that if we are to achieve the Butler target a considerable increase of productivity is required. How important it is that we should achieve this higher rate, because at least three factors over the next 25 years will be working against our efforts. First of all, Britain's population by about 1984 will be increased by about 2½ million people, while our actual working force will be increased by only just over 1 million. Then, too, what about the number of hours worked per week in 1984 ? Many will feel that a higher standard of life involves a shortening of the working week and in preparing this graph I have estimated that there will be a reduction of 6% in hours worked per person. Finally, of course, the graph is influenced by the increase in other living standards which the Butler target requires, thus calling for much greater output of goods from a working population increased by only a small extent and working less hours per week. Can the power of automation help to raise our individual standard of productivity to the required figure ? I hope this Conference will be able to say "Yes!".

(b) *What is the National Attitude towards Increasing Productivity ?*

Never have we been more productivity-conscious, and I am very impressed by the greater interest of a greater number in the worthwhileness of effort in this direction. How has this come about ? Credit obviously goes to many people, but of all pressures the need to increase *production* itself, to achieve greater volume, to satisfy more customers, has probably been the greatest single driving force. If Britain's G.N.P. doesn't increase then *productivity* won't, and it is desirable to emphasise, because few people do so, the close relationship between production and productivity.

Production pressure is closely connected with full employment, which I regard as one of the most desirable individual, company, and national conditions to attain and maintain. Its existence over recent years has involved a drastic readjustment of outlook among managers and men, although there are still too many who appear either to be hoping for or fearing a return to 'easier' labour conditions.

What maintains full employment ? That fourth dimension, confidence in the future, surely plays a great part, and it is encouraging to see it displayed through the many long-term capital investment plans being publicised by our great public and private bodies. In recent months over 27 million sqare feet of new factory floor space and thousands of millions of £'s of capital have been publicly announced (Fig. 8), and if more companies prepared and publicised their future plans of investment it would add to our national stock of *personal* confidence in the future, and make some of us more willing to shed the overcoat of restrictive practices we inherited from our grandfathers.

But even the state of full employment can be improved. The task of achieving the Butler target will create more opportunities for managers and men to expand their efficiencies, jobs and opportunities. The 'situations vacant' columns will continue to

(18) "The Living Brain" by Dr. Grey Walter.
(19) "Towards the Automatic Factory". P.E.P. Broadsheet No. 380, June, 1955.

SOME LARGER CAPITAL INVESTMENT PLANS RECENTLY ANNOUNCED.

Coal	—	£19,000,000 per year.
Electricity	—	£240,000,000 „ „
Gas	—	£56,000,000 „ „
Nuclear Power Stations	—	Probably more than £300,000,000 by 1965.
Railway	—	Probably over £80,000,000 per year.
Roads	—	Probably £50,000,000 per year.
Ford Motor Company	—	£65,000,000 investment programme.
Vauxhall Motors Ltd.	—	£36,000,000 investment programme.

Fig. 8

expand and as prosperity is indivisible, so the variety of new and better jobs open is very great. Some industries, such as those taking the strain of the new discoveries, will naturally lead the demand, but they cannot expect to get recruits because of a falling demand elsewhere. The young men of tomorrow will be in even greater demand and the only way their limited numbers will give the results we want is to get more out of each — to provide him with more skill than his mid-century predecessor. For this reason I hope you will study carefully the Papers given by Professor Matthew and Principal Old, as a programme of Automation will bog down unless considerably more is done to provide more people with skill and with greater skill per person.

What rewards will this bring? Some talk nostalgically about the elimination of the craftsman. Why, there is more skill per person, albeit of a different kind, today than ever before, and Automation will require, not automatons gazing stupidly at dials, but a far greater percentage of designers, prototype makers, production engineers and quality controllers, not to mention better managers to control the lot.

This trend will, I hope, lift the skilled differential so that more are encouraged to acquire the use of more skill. Consider the engineering employee (Fig. 9). This reduction in differential is bad, and I have already said that the future may show a relative improvement in payment for skill. Too many strikes are today being called on this issue, and both skilled managers and men have a legitimate grievance.

It seems inevitable that relatively more people in industry will work upon more skilled tasks, such as designing, controlling, and maintaining, and this skill must be largely provided from existing people, who will improve their status and earnings accordingly. So, parents and teachers, when you see around you, even *amongst* you, evidence which indicates that training and skill don't always get the reward they should, take heart. I believe the future will be more bright, largely because of and not despite the increased power of the machine.

What is man's attitude towards the machine? The introduction of more machine power has in the long run improved his living standards, and will continue to do so to an even greater extent under Automation. But to a greater extent also the problem of readjustment or redeployment will be with us. Full employment gives most men reasonable alternative employment, but most would rather be accommodated within their existing Company. The better the arrangements for accommodating change inside companies the greater will be the acceptance of change, and as we shall require more change so we must accommodate it in better fashion.

Technological redeployment has too often meant temporarily lowered earnings and worsened conditions, and I am surprised that more companies, having achieved long-term success with a new development, do not smooth out the temporary personal readjustments involved. The cost is small in relation to long-term results. These adjustments will become more widespread as automation spreads its effects over a wider group. Mr. Hooper portrays the electronics office, and the rapid growth of mechanised offices will continue, affecting millions of people. Whether this 'office' mechanisation will strengthen white-collar unions I do not know, but as automation will be applied so widely, we shall do well to remember that originally the machine created unions, and they grew and reacted together.

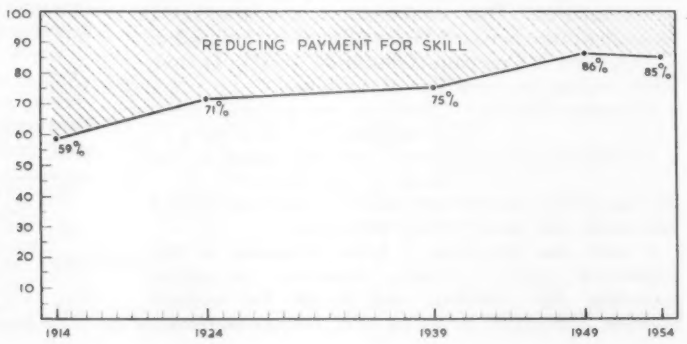

Fig. 9. The Reducing Differential.

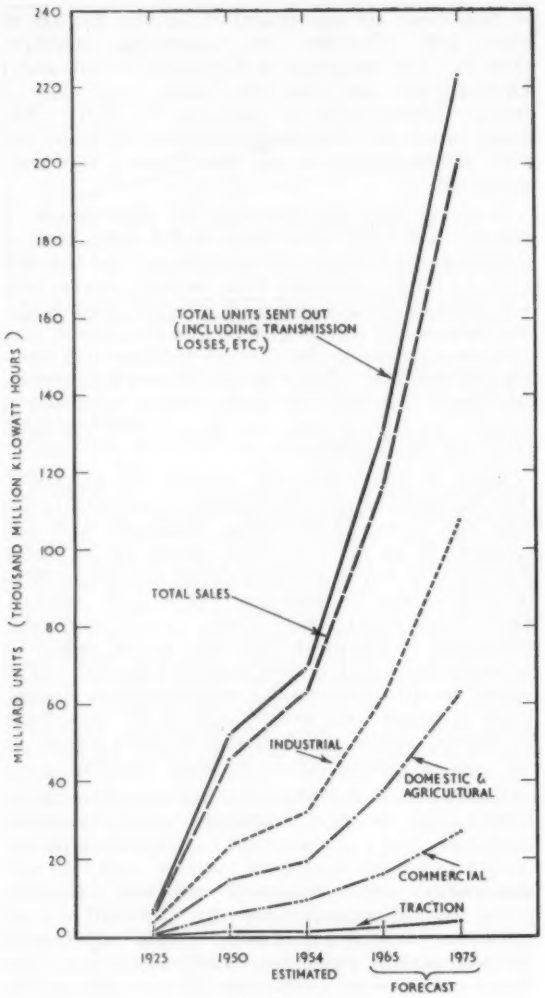

Fig. 10.

But whatever the attitude to productivity, one thing remains; workers are consumers too, and must earn to consume. A series of Automatic Factories with men sitting idle at home is, therefore, fantastic, and our future standard of life depends on maintaining a balance between production and consumption. This conversation is reported (20) as taking place between Walter Reuther, the head of C.I.O., and a Company Official of Ford's, Detroit, while looking at a new line of machines :-

Company Official: "How are you going to collect union dues from these guys ?"

Replied Reuther: "How are you going to get them to buy Fords ?"

The agreement entered into between Fords and C.I.O. last week adds point to this argument.

I wish time permitted a fuller discussion of this important section. Listen, however, to others, including Mr. Fletcher, and decide for yourself whether I am right in saying that, subject to certain safeguards about which we have learnt much recently, the new age will provide many new opportunities for many people.

(c) *What are the Basic Power Requirements ?*

About 27 years separated Rutherford's success at Cambridge from the first atomic bomb on Hiroshima, an explosion which has reverberated through every country in the world. It has rewritten international strategy. Now, "an important stage has been reached in the development of nuclear energy for peace purposes" (21), and we are shown in the White Paper a twenty-years plan which is as fascinating a peep into the future as any modern space fiction.

By 1965 a quarter of our *new* generating capacity will be met by nuclear power stations, but the White Paper is cautious about further progress, and rightly so in view of the many unknowns that still have to be met. But this uncertainty after 1965 underlines the power problem of Britain *circa* 1984. "Almost all supplies of energy in the U.K. are derived from coal and oil" (22), and P.E.P. analyses their respective merits and possibilities in some detail. But both reports emphasise one apparently inescapable conclusion — that coal must be reinforced by nuclear power to provide Britain with enough basic power. The White Paper forecasts a probable demand for electricity up to 1975, and has this to say (Fig. 10).

But is this the last to say on this vital subject! Memories of recent power cuts are still vividly in mind, and to talk of Automation, which must use more power *per capita*, without confidence in the availability of enough bulk power, is absurd.

P.E.P. has attempted a further analysis of the situation (23) and estimates that if we are to achieve the Butler target and its corresponding increase in output and power requirements "there will be a deficit equal to 100,000,000 tons of coal unless either Britain becomes a greater importer of coal or oil imports are raised to undreamt of levels and domestic refinery capacity is expanded accordingly".

How Automation Can Help the Production Engineer

You may be wondering whether as your President, I am, and if so when, going to talk about the mechanics of Automation. My answer, without apology, is to say that before this Conference is over you will be surfeited by technical advice, and be grateful for my restraint in launching upon you a description of computers, feed-back systems and automatic controls.

There are, too, other reasons for my restraint. One, I am only a specialist in generalities; two, in recent years you have embraced the concept of Broadening the Base, which involves a widening of your industrial scope and a raising of your mana-

(20) "Trade Unions' Fears about Automation" by Hollace Ransdell. (C.I.O. News.)

(21) White Paper on "A Programme of Nuclear Power"—Cmd. 9389.

(22) "Planning" Vol. XXI. No. 377 — 'Fuel for Twenty Years'.

(23) "Towards the Automatic Factory" P.E.P. Broadsheet sheet No. 380, June, 1955.

gerial sights. The first impact of Automation will come upon you, the supervisors and managers of industry, who must apply the new techniques at a point where they help or hurt most, this is to the body of men and women who make up the bulk of the *organised* working force, whose memories of the past are still too often framed in black.

It has taken production engineers many years to realise that their work is successful only when it is accepted by and implemented by men, and a brief summary of the past may prove my point. This Institution reflects the modern concept of production as a specialism. We were born in 1920, following the realisation by a few pioneers that war and peace would now be fought successfully only if those participating were supplied with more machine power to multiply manpower. Lloyd George was the first politician to see this clearly and to act accordingly.

Our early efforts were naturally concentrated on the direct machines of production in the engineering industry — the lathes, millers, drills, etc. The development of tungsten carbide as a cutting material led to more detailed consideration of the tool on the machine, and it is interesting to note that it has taken at least 25 years for machines to be generally redesigned to take advantage of cutting tool development. I doubt if it will take as long to utilise the new electronic tools becoming available.

Fig. 11 shows what I believe to be the significant steps in our development, and it is interesting to trace the pattern. First the productive machine itself, then its tools and then an integration of the two, where both were considered as a team. From this emerged more serious consideration of the productive materials, how they were specified and moved from raw stage to finished parts and, through time and motion study, how productivity could be measured and efforts rewarded. "Production Control" was the broad term used.

Logically this brought managerial considerations into our orbit, with a growing realisation that man-management was a production engineer's job as well as machine management. A review of our Journals over the years shows clearly how these trends were reflected in Section activity.

A significant post-war trend is seen by our great attention to materials handling, which enables us to move materials more effectively between machine and machine. Modern transfer machines, as described by Bezier and Graves, are logical developments. I recollect, in 1950, drawing attention to a simple case, (Fig. 12), which illustrated the time lost by

THE DEVELOPMENT OF PRODUCTION ENGINEERING

MECHANISATION

The Productive Machine Tool

The Cutting Tool

The Integration of the two.

The Productivity of the Machine and the rewards of those who work on it (Production Control.)

Man-Management

Material handling.

Transfer Machine

AUTOMATION

Fig. 11

what accountants call 'work-in-process', and I call 'work-in-stagnation'. Look at the average engineering works even today, and observe how much material is not, at any given time, being worked upon.

Automation Through Control Power

And now we have Automation, in many ways a logical development of previous trends. Man will continue to have more power delivered to his elbow through higher-powered productive machines, and through lifting and shifting equipment linking machine to machine, factory door to factory door. Automation will enable this power to be used more effectively by giving more power to man's brain, helping him to control, assisting him to decide, relieving him of routine, providing—as Mr. Sargrove says—more 'conscious' machines.

Automation, then, is a logical successor to other tools placed at our disposal, such as tungsten carbide, fine measuring equipment, T.W.I., Work Study and

Progress of Part No.

Material stored	10 months =	7,200	hours
Waiting time between machines		797	hours
Actual time on process		1·3	hours
		7,998·3	hours

$$\frac{\text{Process time}}{\text{Total time}} = \frac{1 \cdot 3}{7{,}998 \cdot 3} = :0016 \text{ per cent.}$$

Fig. 12. Work in Stagnation.

material handling equipment. Why, therefore, are we excited and possibly fearful about Automation? I believe the main reason is that while we may accept the idea that a machine should take over our brawn, it is quite another thing to agree that it should take over our brains. Do you remember Capek (24) who created the "Automaton" and whose factory manager in R.U.R. said "any one who has looked into human anatomy will have seen at once that man is too complicated, and that a good engineer could make him more simply". Wiener and Walter provide us with modern analogies between the organisms of machines and men, although Butler (25) brilliantly portrayed, over 50 years ago the possible domination of man by the machine.

I fear nothing in Automation that I do not fear now. It seems logical and inevitable that if we are to achieve a higher standard of life we must multiply our brawn power, and this surely means that brains must be utilised more effectively in controlling and augmenting our brawn. Automation, largely through electronic means, brings new and exciting tools to our aid, and as production engineers and managers we should understand, explain and apply them as a direct contribution to a higher standard of life.

Diebold (26) says that "it is not difficult to understand why primary attention has been focussed on the control aspect of the automation problem. It was the electronic and communications research of World War II that lifted the idea of a fully automatic factory from the realm of science fiction into that of serious discussion. The development of high-speed digital computers, or 'giant brains', as well as mechanisms for directing guns upon rapidly moving aircraft, provided solutions to some of the most important basic automatic control problems".

So once again we find war as the hothouse which forced the growth of discovery. The cold war, which forces nations to spend a large part of total income

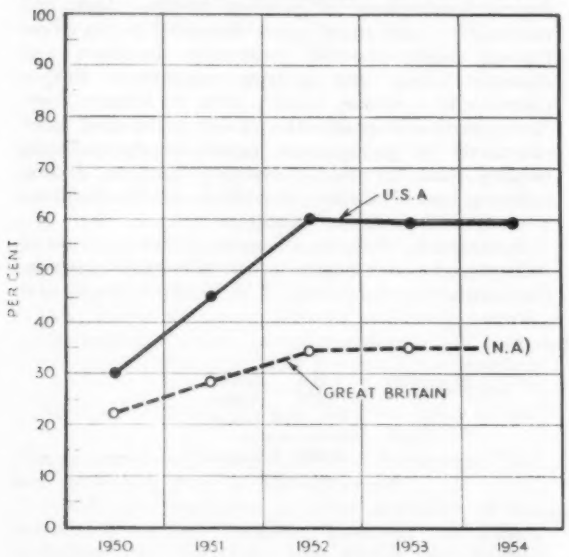

Fig. 13. Percentage of Taxation spent on Defence.

on defence research (Fig. 13) is likely to be with us for years, and in defence research we often find inspiration and assistance for the works of peace. It is one way to obtain greater value from defence cost and realising that probably more than 50% of Britain's total electronics effort is being devoted to defence we must surely see that there is much to find if we look.

How Can This Conference Help ?

What are we likely to find at Margate ? In the display of equipment and Papers is a wealth of information and the men who should dig most energetically are the managers of industry, the men who, because of the complexity of their tasks, require more help from modern tools than any other class. Will electronic computers and such complex control equipment help managerial effectiveness ? Yes, if they enable fewer, but more vital control statistics to be available more quickly. Look at the case studies at this Conference and enquire within whether they will make you, a manager, more effective—whether they will enable you to delegate to a subordinate *or a machine* some of your existing preoccupations and leave you with a nett gain in personal effectiveness — whether you, for instance, will be able to spend more than 23 minutes on any one job (27).

Will electronic accessories to the productive machine such as described by Williamson and Stokes enable you, the manager, to be helped ? Remember that this type of equipment was developed because a manager was worried by high tooling costs for small batches. Will the ultimate remedy be worse than the malady ?

Will the greater precision of quality and quantity provided by the weighing, batching and inspection machines described by Bourgeois and Sargrove help you to sell better goods more effectively ?

Will rapid electronic communications enable members of the Board to decrease tiring travelling time; for example, will the future televised Annual General Meeting on an I.T.A. hook-up be a retrograde step, compared with the present method of collecting all shareholders in a London office ?

Will the instrument control systems described by Young, McCallum and Peacock expand managerial knowledge and control, or will this increased help be neutralised by worries over maintenance problems and personnel ?

Will Automation involve too much rigidity of design in order to justify large scale production, or will the designers be able to overcome this and provide a nett gain by reducing unnecessary variety, cutting lead-time (28) and costs ?

Will the improved production control made possible through such methods as those described by Hooper

(24) "R.U.R." by K. Capek.
(25) "Erewhon". The Book of the Machine. Samuel Butler.
(26) "Automation — The Advent of the Automatic Factory" — by John Diebold.
(27) Professor Sune Carlson in his book "Executive Behaviour" says:- "Only 12 times in 35 days did the Chief Executive work undisturbed in his office for an interval of more than 23 minutes".

be neutralised by an increasing reliance upon and difficulty in controlling bought-out electronic specialities ?

Will the 'remote control' possibilities of atoms and electrons relieve the mind of safety problems, or will, as often, new techniques create new hazards ?

These are the sort of questions you are likely to ask yourselves many times. They will probably differ little from questions you have been asking for years : the principal difference is, that the future will bring relatively more questions, more managers will have to ask them, and much more personal strain will come upon those who cannot find satisfactory answers.

Summing-Up

It is difficult, with such a subject, to know when to stop but this is, after all, an opening address and not a compendium. Let me, therefore, sum up and leave with you the more important points I have endeavoured to make.

I assumed that the objective of Automation is to increase our national standard of living, and as a target I have used Mr. Butler's stated aim of a doubling of our national standard by, say, 1984. Every consideration of Automation, its problems, its possibilities, is therefore linked to that doubled standard of life for all and not merely to one section of our people.

The term "Automatic Factory" is misleading and may be dangerous. It implies a restricted definition of the word 'Factory', which is, after all, a place where many activities are performed, of which a minority of those employed may be machine minders and likely, therefore, to be displaced by the machine. Automation may, however, be applied to a wide group of departments and activities, including the office, and some sections of a factory may well be described as Automatic, still however making it necessary for the Company to employ as many and probably more skilled people than before.

The First Industrial Revolution

In considering the future we are wise to review the past, how that conditioned the present and how existing problems must be solved to achieve a successful future. I, therefore, went back to Britain's first Industrial Revolution and sketched briefly the forces which transformed Britain into the first workshop of the world, what caused that transformation and what legacy it has left with us today.

I believe that the first Industrial Revolution was preceded and stimulated by at least two significant forces, one, a scientific revolution and two, a large scale development of commerce and its close friend, consumption. Demand and consumption were closely allied to serve the masses.

The scientific revolution played its part in making possible large scale practical applications of which the steam engine, harnessed to rotary power, was the significant leader. This revolutionised industry by making possible the development of large factories and industrial towns. It was, too, the catalyst which encouraged many other discoveries and industries such as the textile, iron and steel, and machine tool.

An important part of the first Industrial Revolution was the great change which took place in man's working and social conditions. He was uprooted from a peasant village life to a factory existence in which many excesses were unfortunately committed in the name of production.

I summarised this period by saying that the first Industrial Revolution had three principal effects; it "widened the gap between rich and poor, novelty and custom, and between town and country". I suggested that each of these gaps has been substantially reduced in the subsequent years by other forces which, as often, correct excesses and restore balance. In Automation we call it 'feed-back!'.

These compensating forces have been numerous, the more important being new inventions such as the electric motor and internal combustion engine, the growth of Trades Unions, and of a widely increased social conscience, and, partly through this, a much greater understanding among managers and men of man's place in his working environment and his relationship to the machine.

The Second Industrial Revolution

This led us to an examination of a current question which is becoming linked with Automation; "Are we on the eve of a second Industrial Revolution ?".

My view is that the second Industrial Revolution started some years ago "when a significant number of people realised that in developing the machine age we had forgotten man". The next few decades of the second Industrial Revolution will "be devoted to a greater means of uplifting man's own power by (a) augmenting his brawn power through mechanisation (b) augmenting his brain power through more control power, and (c) controlling his emotion power by better managerial power."

The significance of Automation as a tool of the second Industrial Revolution is its ability to multiply control power which will be largely applied through the new possibilities of electronics, which, as Diebold suggests, developed widely during the last War and through computers and many other such devices brings to our aid a wide new range of control possibilities.

The Framework of Automation

In order to dispel an erroneous impression that the main purpose of Automation is to displace labour, I thought it desirable to examine our objective, a doubled standard of living, and to see what tasks its realisation would impose on industrial Britain. I considered that three principal and several secondary requirements confronted us of which the most important seemed to be :-

1. greater ability to translate research into reality more quickly;
2. a wider and greater recognition of man's place in the industrial community;
3. a considerable increase in personal productivity.

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(28) Project Tinkertoy under the authority of the National Bureau of Standards, U.S.A., claimed, inter alia, a reduction in 'lead time' through Automation.

Some important limitations came to the surface in considering No. 3, the most prominent being :-

(a) the need to increase confidence in the future, and the necessity for accepting a greater rate of change;
(b) the need to reward skill more adequately;
(c) the need to reconsider the power supplies which must support our increased activities.

How Automation Can Help the Production Engineer

I endeavoured to show that Automation is a logical extension to our work over many years, and it will call for no major reconsideration of our attitude or the way we apply our techniques. The emphasis over the next few decades will be on greater control power applied to greater mechanisation so that we multiply brawn power more effectively through better brain power. A feature of Automation is that it more easily provides this greater control power in many ways, of which the so-called electronic 'brain' is but one.

It is not easy to recognise the ability of even the most modern machine to take over part of our brain power. I believe with Kipling that "machines are nothing more than children of your brain", but surely if we are to extend our 'control' we must expand what is essentially a 'brain' task, and subject to man's overall control and the limited instructions he feeds into the machine, the latter, through Automation, is now capable of 'conscious' thought. Machines such as an electronic computer, or those described by Sargrove and others, have, within limits, a memory and an ability to produce information and to feed this information to other machines, which themselves may exercise the brawn power.

There is surely a great difference between, on one hand, regarding Automation as a rival to one's brain and, on the other, using it to augment and expand one's own brain power.

Automatic Factory—Dream or Nightmare ?

And so to my original question. I must come back again to man, because all things including Automation are for his benefit. Automation does not call for a drastic reorientation of our outlook, although it does open up wide new possibilities, just as the jet engine opened up new possibilities to an aeronautic engineer and enabled him to go through a hitherto unpenetrated 'barrier'.

Its impact on managers concerns me most, because on them the strain of the future will continue to fall. Automation will provide many headaches but paradoxically it may, if it can augment the manager's control power, ultimately help him. He should, I believe, regard it as such a potential helpmate and those who research and develop should particularly endeavour to help the manager when designing new equipment or technique. More bulk power without more control is useless and dangerous.

The impact of Automation on the mass of working people, is not, in my view, likely to bring them new worries. The great expansion in mechanisation is conditioning men to accept change and the principal difference will be seen in three ways :

(a) there will be a speed-up of change;
(b) automation will bring mechanisation into a wider group of industries and jobs;
(c) the opportunities for skilled men will be greater.

There are, too, at least three 'feed-back' forces which will prevent instability and disorganisation among the working force. First of all, some always lead and others follow : "For several generations of gradual change the domestic and factory systems existed side by side" (29), and even today we see wide variations in the performance of individual companies. There are some managers who have probably not heard of this Conference ! There are those who say with truth that they started to apply Automation years ago. Secondly, we are learning much about the better application of new methods to those vitally affected. This is the important beginning of our second Industrial Revolution and despite current difficulties let us remember that we are only at the beginning.

Thirdly, industry will provide its own 'feed-back' control. Continued prosperity and full employment will stimulate Automation and other better methods, and as an American friend said recently : "It is fortunate that Automation comes in a period of great demand !" Any recession will cause a sharp reduction in the application of new ideas, in other words, Production and Productivity are closely allied.

Dream or nightmare ? I can do no better than again quote Walter Reuther (30) who recently said this :

"Without facts and study, we are apt to bump into the electronic-automatic age with a resounding crash. The least we can do is to use our human radar equipment — our still imperfect, God-given brains and heart — to explore the future unknown.

"Our responses may be neither automatic nor electronic, but if they start with good will and imagination, there is no reason why all of us — workers, consumers, small businessmen, farmers and investors — should not benefit from the second Industrial Revolution."

One final comment about the fine display for which we are grateful to the exhibitors. Take time out to see what is on show, and while here particularly look out for one of the most spectacular exhibits at the Conference.

It comes in a variety of sizes and specifications, weighing in its medium size about 160 lb. It has a built-in computer complete with a fine memory unit and feed-back controls. I would particularly ask you to examine its servo-control system and the ease with which it can be adapted to a wide range of jobs. Unfortunately, it does require quite some skill to get full output from it but once set and reasonably maintained it performs a fine job. It has, too, the advantage that it can be reproduced by comparatively unskilled labour. Its name ? A three-letter word beginning with 'M' !

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(29) "English Social History". G. M. Trevelyan.
(30) "Workers Face the Age of Automation". Walter P. Reuther.

THE AUTOMATIC MECHANICAL PROJECT FACTORY: A SIGHT OF THINGS TO COME

by H. J. GRAVES, M.I.Prod.E.

Mr. Graves received his engineering training with The Daimler Company at Coventry. He joined The Austin Motor Company in 1919 as Planning Engineer and was appointed, in succession, Chief Planning Engineer, Chief Buyer and to his present position as Supply and Equipment Manager and Local Director.

Mr. Graves

THE application of automatic operation to manufacturing processes is not new. It has been applied for many years to the manufacture of textiles, hot strip mills, cigarettes, the chemical industry and other processes where very large outputs are required.

In the motor car manufacturing industry—and the majority of the applications of automatic operation in this Paper apply to this industry—it is only within the last few years that automatic manufacturing processes have come to the fore. Special machines with automatic work transfer and self-acting clamping mechanism were built in 1923 by Morris Motors, for machining monoblocs and gearbox castings. These were described in Frank Woollard's Paper presented in December, 1952. Like other new developments, they were perhaps ahead of their time, as other processes in the manufacture of the motor car have not kept pace with them. However, whatever the reason no further examples of this type of machine were produced until about five years ago; since when rapid strides have been made in the U.S.A., France and this country, with fully automatic transfer machines.

The Americans have coined a word which adequately describes a production process linking together a number of automatic machines into one integrated process—"Automation". This word was rarely heard in this country twelve months ago, but is one which has recently made the headlines in numerous newspapers, magazines and technical journals. A definition given by Mr. Hautau, an American expert in this field, is—the completely automatic manufacture, assembly and preparation of products for shipment; in fact—a push-button operated factory.

A Healthy Start

The completely automatic factory may be a dream of the future, but partial push-button factories or production lines exist already in some industries and with the latest machining and assembly lines and metal stamping, forming, welding and body assembling, painting and finishing lines, the automobile industry has made a healthy start and will undoubtedly make rapid strides in the next few years.

The large increase in British motor car production since the War, and the increasing tendency of manufacturers to commonise their main units, e.g., engines, gearboxes, rear axles, between models, resulting in much larger requirements of individual components, has created the volume which will enable the new automatic machining lines to be fully employed, and without which it would not be possible to justify the considerable capital expenditure for such high production machines.

It is not many years ago that one operator assembled an engine or gearbox on a stand entirely by himself, or a group of five or six men assembled a

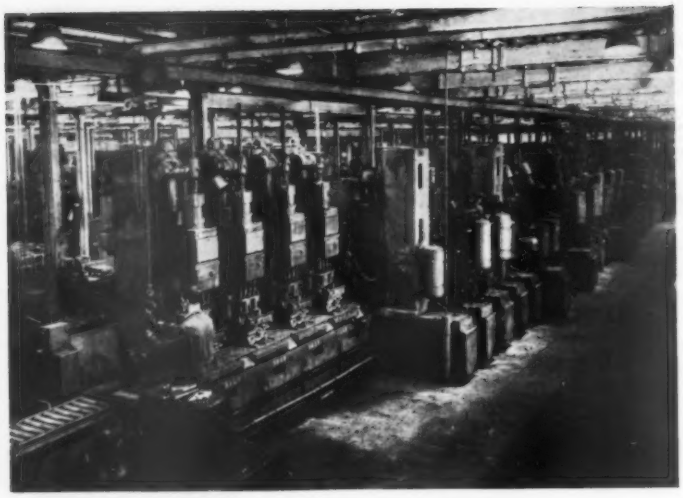


Fig. 1. First stage transfer machine for monoblocs at Austin Motor Co., drilling tappet holes, milling bearing cap cheeks, etc.

motor car chassis. Considerable hand fitting, scraping and bedding of bearings was necessary and the quantities required were small. The first stage in breaking up this procedure was the introduction of the grinding machine and the rapid advancement in the machine tool industry whereby accurate interchangeable machined parts were produced, and the necessity for hand fitting, etc., disappeared. The next step was to semi-automate the assembly by putting the engine or chassis assembly on to a moving belt or conveyor. There are many excellent examples of moving track assembly lines in existence and the day is not far distant when we shall see attempts to build completely automatic assembly lines or machines and, indeed, this has already been done successfully on some smaller assemblies.

The First Step

The first step towards automation in the machine shops was probably brought about by the fatigue of continuously lifting and loading into jigs heavy components, such as cylinder castings. Gravity roller track was placed between the machines, so that the castings could be kept off the floor at working level and loaded into the jigs with minimum effort.

With the ever-increasing volume called for by the motor industry, necessitating very high capital expenditure for new buildings and plant, the engineer has looked for a means of applying to the machining line what he had previously applied so successfully to the assembly line, i.e., to join together into a continuous straight line all the machines required to machine a component so that it can progress from one operation to the next automatically.

These machines are known as " transfer " machines, and in order to simplify their manufacture, reduce costs and at the same time make it possible to re-group if necessary, the particular transfer machines which we are using have been built up from a number of standard units; each machine comprises a number of 2 or 3 station beds bolted together to form a backbone of the machine with a standard loading station at one end and an unloading station at the other. To the centre beds are bolted the required number of branch beds on which are mounted the columns, unit heads, multi heads, etc. (Fig. 1).

A similar method of using standard units is in use at the Renault factory in France, but in their case they join the bed sections together with a bridge piece. I do not intend here to describe in detail our transfer machines. They were very fully dealt with by my colleagues, Mr. Griffiths and Mr. Holbeche, in their joint paper to the Coventry Section of the Institution in November, 1954. In addition, we have some 150 rotary indexing type machines which are found to be particularly suitable for machining certain components. These are built in the same manner from standardised circular base units, rotary tables, standard extension beds and columns, and using the same range of unit heads as the straight line machines.

Introduction and extension of the unit construction principle to the design of many elements of transfer machines has helped to reduce costs of designing and building, at the same time providing a degree of flexibility which enables the machines to be adapted to changes in the design of the component arising from the introduction of new models.

Both in-line and rotary types of transfer machines fulfil that most important production principle of making the machining process continuous. They often realise the ideal of completely machining the component on one machine. The transfer machine represents a major step forward on the road to full automation.

It is believed that the Russians are using standardised units in their transfer machines, but with the exception of the heads the Americans have not generally followed this method of construction.

There are several instances where machine tool manufacturers have used standard machine tools and designed an automatic mechanism to load the work into and out of the machines and also transfer it

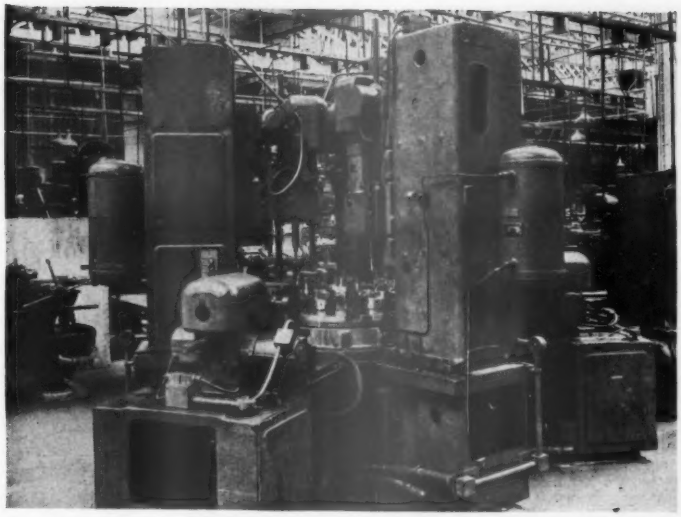


Fig. 2. Typical rotary indexing type machine.

from machine to machine—an example being The Norton Company, who have developed an automatic crankshaft pin grinding unit comprising four crankpin grinding machines coupled together, over which are five transfer heads travelling up and down runways located over the machines. Crankshafts are brought to the machine on a conveyor, one of the five transfer heads picks up the shaft, carries it horizontally to the right and lowers it into the first station, at the same time the other transfer heads have handled four other crankshafts advancing the last one to the conveyor, which takes the work to the next operation. The automatic cycle includes operating the steady rest, wheel in-feed, gauging and wheel truing, which is performed after a pre-set number of cycles. The production cycle time is said to be 1 minute to $1\frac{1}{4}$ minutes per shaft (Fig.3).

Similar automatic mechanism has been developed by Lo-Swing and Sunstrand for the turning of camshafts, in which the work is automatically loaded into and transferred from machine to machine.

These applications of automation by American machine tool makers, in which the automatic devices are built into and incorporated with the machine, are expensive and unless quantities are required, it is doubtful if the capital expenditure can be justified.

If we are to develop towards full automation in this country, our designers and engineers must concentrate on developing automatic transfer of work from one standard type machine to another, and coupled with this, automatic loading of the work into and out of the machine. We are familiar with the simple procedure of connecting a line of machines with a number of gravity runways or shutes so that

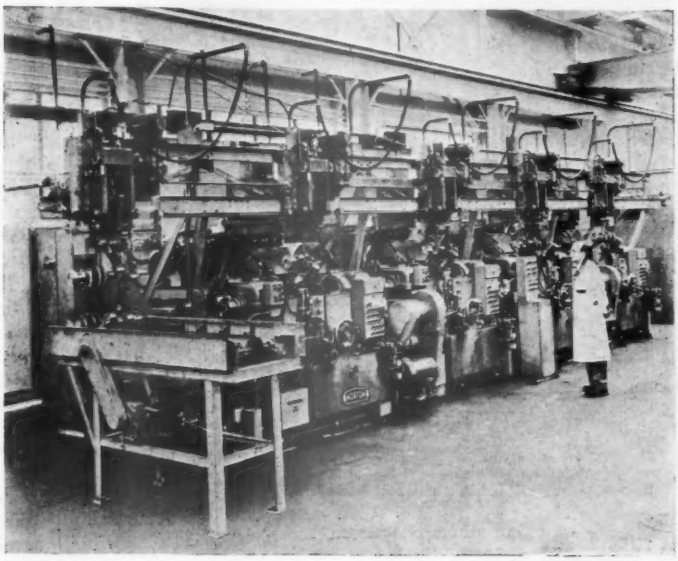


Fig. 3. Four-station automatic crankshaft pin grinding transfer machine manufactured by the Norton Company.

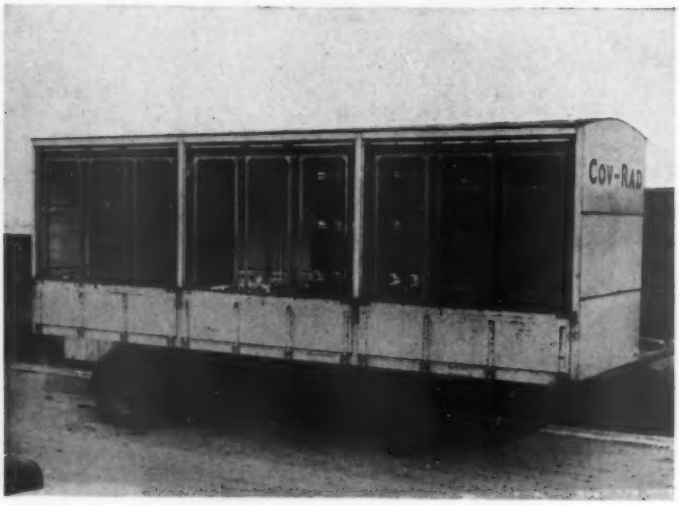


Fig. 4. Radiator trailer with capacity for 378 A40 radiators.

the operator always has a component readily to hand. On heavier work, we have gravity roller track connecting machine to machine and equipped with indexing or roll-over devices for turning the component through 90° or upside down without manual effort and, where possible, these devices operate automatically. In America, the Ford Motor Company have linked the machines on their cylinder block lines with completely automatic air operated shuttle devices which pull the casting out of the fixture of one transfer machine and push it into the next. There are three types of shuttle: (1) lengthwise to push parts lengthwise; (2) broadside to push parts broadside; and (3) overhead to push parts either broadside or lengthwise as required. Automatic turntable and roll-over devices are provided where necessary. The result is a completely automated production line, push-button controlled. The next step to obtain the automatic product factory must be to feed automatically the products of these automatic machine lines to automatic assembly lines or machines.

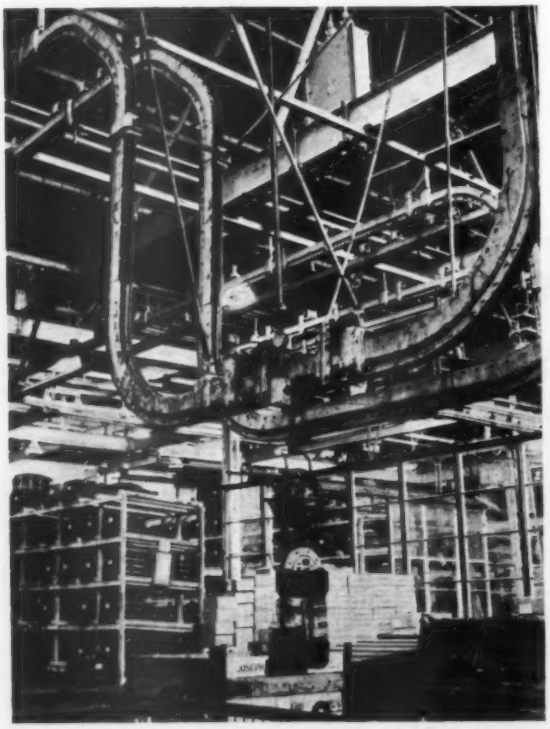


Fig. 5. Rest and run conveyor, showing loading point in the finished stores.

It is perhaps in the movement of material through the factory that the greatest benefit from the use of automatic devices will be obtained—how many of us know the cost of handling all the material used in the manufacture of a modern motor car ? It is true that a great deal of interest is being taken in mechanical handling, but there is still room for improvement in the majority of factories, and a great deal of cost is hidden under the category of overhead charges.

A brief outline of what has been done in the Austin factory since the War may be of interest. Major components such as radiators, road wheels, tyres, etc., are delivered in trailers which are backed into docks on our Receiving Decks. The components are located in mobile stillages, which are pulled off the trailer on to the Deck as required. They are then hung on to conveyors, which take them to their assembly point on the main assembly tracks. These trailers are, in effect, mobile stores (Fig. 4).

Other components are delivered in standardised containers made in three sizes. They are unloaded from the vehicles by fork truck and placed in stillages in the stores. The parts are loaded by the storemen into specially designed carriers attached to Rest-and-Run conveyors which take them to their assembly

point. A special feature of these conveyors is that when the carriers reach the assembly point, a number of carriers are held stationary by means of a selector pin. As the operator removes the component, he presses a button and the empty carrier is started on its journey back to the stores. Simultaneously another loaded carrier moves automatically into the place vacated by the previously emptied carrier (Fig. 5).

The same type of conveyors are also being used on our crankshaft and other machining lines. In this case the work carrier is power-driven between each machine. A batch of carriers is held stationary on the conveyor until required by the operator. When the operator removes a shaft, the empty carrier automatically moves to a new position and waits until the operator hangs the machined shaft on to the carrier, when it automatically moves to the next machine and the process is repeated (Fig. 6). Future development will be to devise means of automatically taking the component from the conveyor, loading it into the machine, and when the operation is completed unloading it from the machine and returning it to the conveyor.

The new engine and gearbox assembly tracks have many new features. A marshalling basket platen and an assembly fixture are moved along on a slow moving chain, the unit being progessively assembled at predetermined stations along the length of the track (Fig. 7). When the engine is completely assembled, the assembly and marshalling platens are lowered on to a fast moving chain, which returns them to the beginning of the track.

The running in of the engine is also performed on the building track. This is done by means of a short track similar in basic design to the assembly track and parallel to it, with elevators at each end, carrying platens incorporating a drive and pump unit. The two tracks are synchronised and the drive is automatically engaged with the engine and continues to motor it for some 40 feet of travel, when the drive is automatically disengaged (Fig. 8).

Similar conveyorised applications are common in most of the large automobile manufacturing plants, and considerable progress has already been made towards the automatic product factory. There is still a great deal more to be done before all the processes are integrated into a completely automatic installation.

Smaller parts are particularly suitable for assembling in specially built machines. The component parts

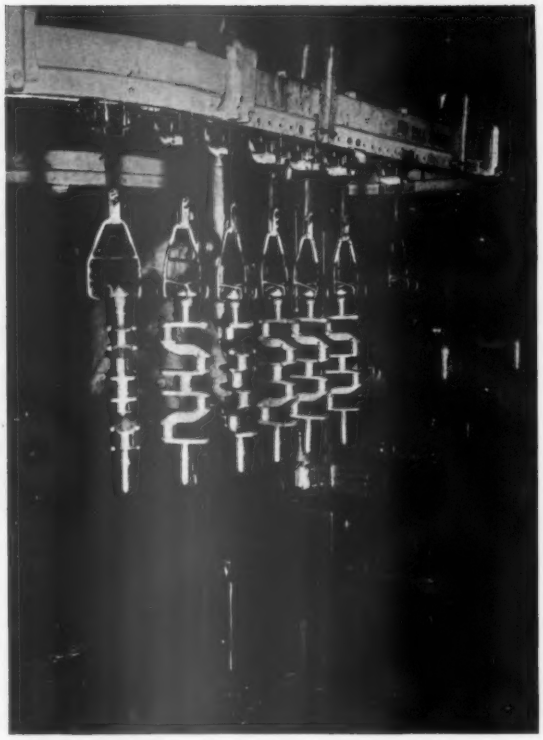


Fig. 6. Rest and run conveyor handling crankshafts between operations on the machining line.

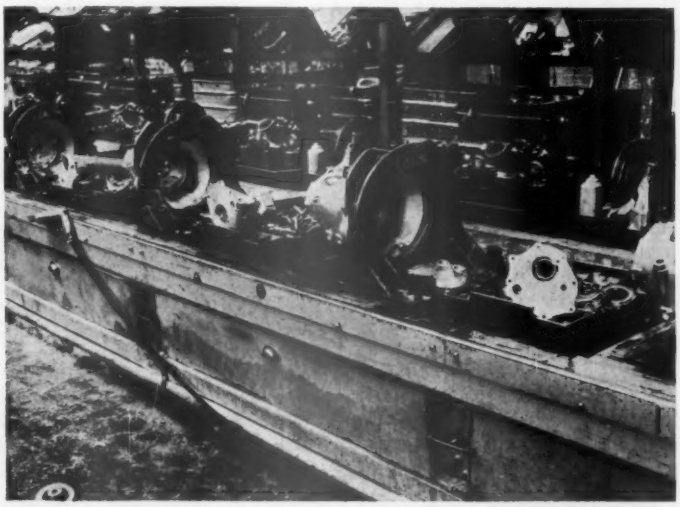


Fig. 7. Typical section of the assembly track, showing an assembly fixture and marshalling basket platen at Austin Motor Co.

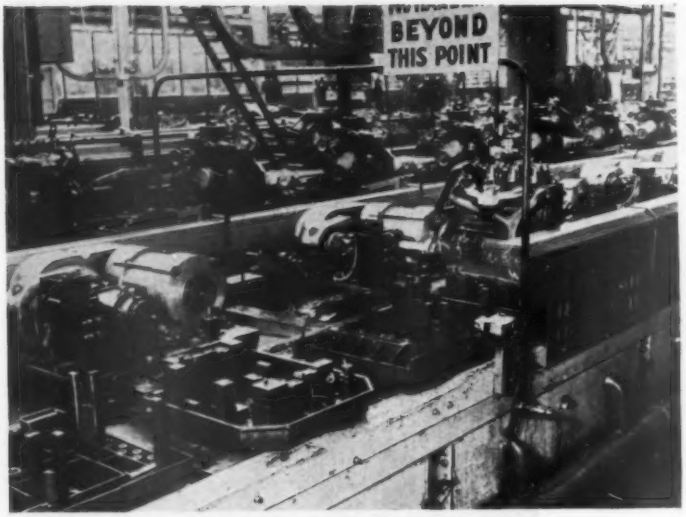


Fig. 8. Close-up of an engine running in unit as used on the assembly track.

are loaded in hoppers and automatically fed to the machine, which is completely automatic. Ball bearings, petrol pumps and small electrical assemblies have been assembled in this manner. Fig. 9 is an example of automation applied to assembly, developed by Joseph Lucas, Limited. A commutator comprising 60 pieces is assembled by one operator in 8 seconds, a saving of 72 seconds each and 18 operators on a day and night shift.

Perhaps the earliest development in automatising press operations was the introduction of coil feed to the press, rotary indexing and dial feed presses. There are many press lines both in the U.S.A. and this country, where a group of presses is set-up for performing all the operations to manufacture a component, in which coiled stock is fed to the first press for blanking or drawing, the blank transferred by means of a mechanical hand device or by power conveyor from press to press.

A further development in the U.S.A. has been the automatic manufacture of motor car chassis frames at A. O. Smith Corporation and at Ford, where the frame members are presssed on lines of presses, the work being automatically transferred from operation to operation, and then through automatic progressive welding machines for assembly and finally through painting to completion. These lines only require maintenance men to look after the mechanical devices and are completely automatic in operation.

Increasing Use of Transfer Presses

Increasing use is now being made of transfer presses, recently introduced in Germany. Basically, the transfer press is an eccentric press having a series of tools fitted on a broad slide. The work piece is transferred from one tool stage to the next through the agency of work gripper slides, whose movement is synchronised with that of the tool head. The ingoing material is in the form of a continuous strip fed from a coil, or as cut blanks; after passing the last tool stage the workpiece leaves the press as a finished component (Fig. 10).

The capital cost of a transfer press is greater than that of several small eccentric presses. On the other hand, however, material costs are the same, labour costs are lower, as only one operator is required. Power requirements are less and floor space is saved—a very important point under modern press shop conditions.

Similar results can be obtained by using a line of standard eccentric presses linked by simple mechanical means for transferring the work from press to press. Fig. 11 shows a line of presses used by Joseph Lucas, Limited, for producing head lamp bodies. The capital cost of a set-up similar to this is about £25,000, as compared with the transfer press for a similar job—£35,000 to £40,000. The production rate is 1,000 per hour and in both instances only one operator is required. Floor space is admittedly greater than with a transfer press. Where very high volume is required a case can be made for purchasing a transfer press, but for lower volume production, and with some ingenuity on the part of the Planning and Designs Engineers, it may be preferable to adapt standard eccentric presses.

The painting of the modern motor car body is another branch of the motor car manufacture which is rapidly becoming automised. Rotodip plants have been installed by a number of manufacturers to deal with the preliminary rustproofing and priming of the body. They are capable of dealing with about 20 bodies per hour and are, in consequence, machines of considerable size and mechanical complexity, being fully automatic in operation, including the loading and unloading of the bodies into and out of the plant.

In most English plants the spray painting of the primer and colour coats is performed by sprayers, either working on both sides of the body simultaneously or on one side at a time. In the U.S.A.

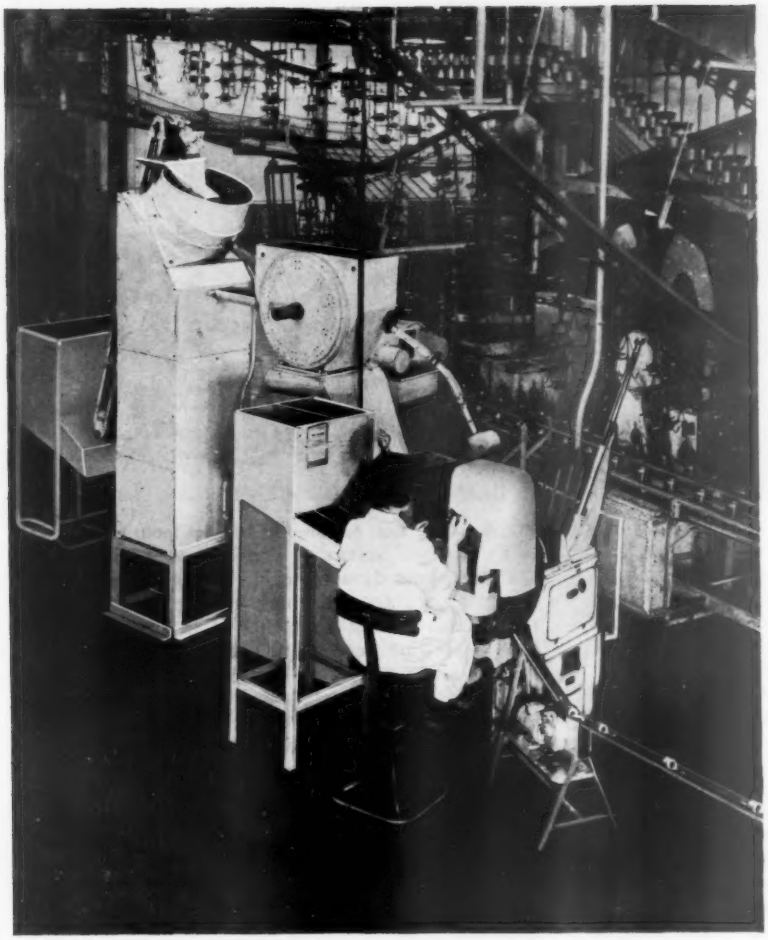


Fig. 9. An example of automation applied to assembly of commutators developed by Joseph Lucas, Ltd.

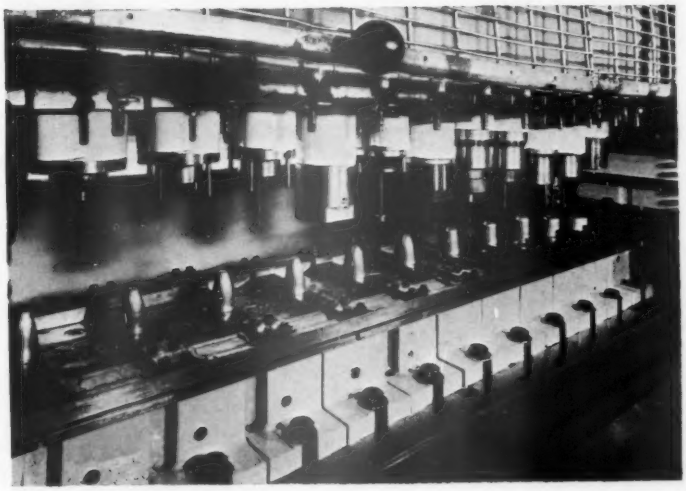


Fig. 10.
Close-up of a Schuler transfer press, set up for producing motor car side lamp bodies complete, at the works of Joseph Lucas, Ltd.

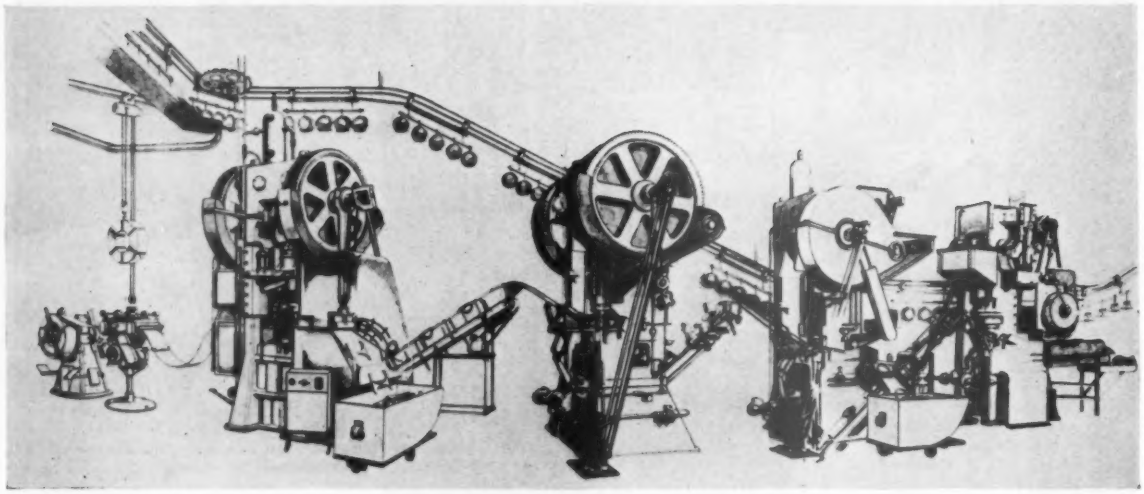


Fig. 11. Illustration showing a line of presses used by Joseph Lucas, Ltd. for producing head lamp bodies.

some paint plants are already being mechanically operated. Spray guns move along tracks conforming to the contour of the body, automatically spraying the sides and tops of the bodies, generally covering about 80% and leaving only 20% at the front and rear ends to be hand sprayed. Undoubtedly before long bodies will be completely sprayed with both undercoat and colour coats automatically.

Electrostatic painting is being used successfully for finishing wings, road wheels, chassis, etc. The article to be painted is passed through a painting booth containing a grid conforming to the shape of the article, the grid being charged with a positive high voltage current. The spray guns are so arranged that the paint which is sprayed through the grid becomes charged with a positive potential and is attracted to the article to be painted, which is hung on a conveyor and is at a negative potential.

Photographs show plant in use at the Austin Motor Company for the painting of road wheels (Fig. 12) and chassis frames (Fig. 13). Both these plants are completely automatic and one advantage of this method is the saving in paint used. Our experience has shown approximately a 50% saving, due to the paint being electrically energised and attracted to the article to be painted, there being very little overspray and wastage of paint and consequently less cleaning out of the paint booths.

In the forge shop, continuous press forging is more suited to automation than the older drop hammer forging methods. Consequently the drop hammer and the steam hammer are being replaced in automotive forge shops by rolling machines, and mechanical and hydraulic presses integrated into co-ordinated lines by automatic material handling devices. The familiar forging shop furnace is being replaced by fully auto-

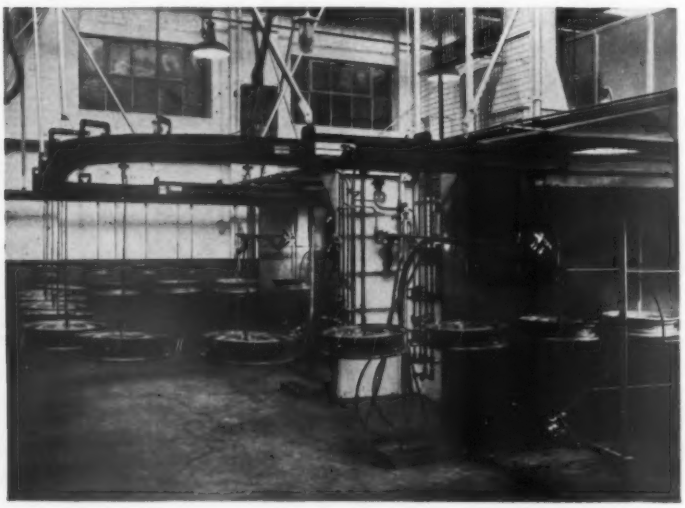


Fig. 12. Close-up of an electrostatic paint plant applied to the painting of road wheels.

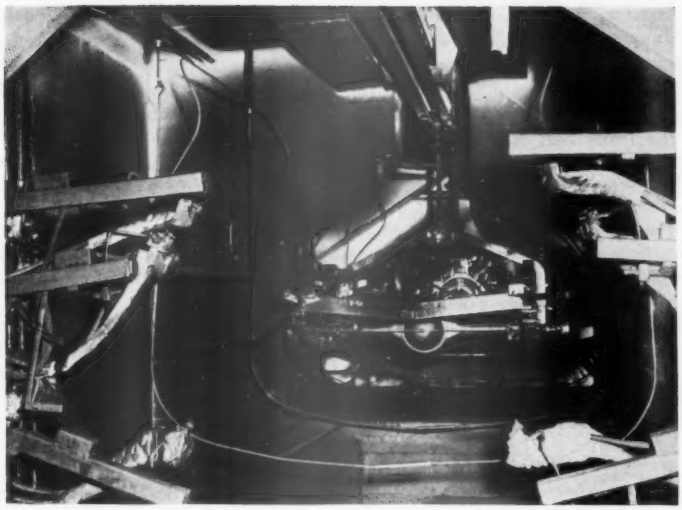


Fig. 13. Close-up of an electrostatic paint booth for painting motor car chassis.

matic rotary furnaces, or by induction heating. These semi-automatic forging set-ups are particularly suitable for the forging of connecting rods, crankshafts, etc. The heated billet is picked out of the furnace by means of a hydraulic hand and passed to the reducing rolls, from here it is moved automatically to a large mechanical forging press, where the shape is forged. It is then pushed out of the press and automatically conveyed to a clipping press for removal of the flash. The completed forging, still travelling by conveyor, is taken to shot blasting and heat treating operations. Sometimes, for convenience, the group of presses with their furnace are arranged in a circle instead of in a straight line.

The use of these large powerful presses instead of steam and drop hammers has resulted in forgings being produced with less allowance for machining, an important factor when it is remembered that on an average up to 30% of the weight of the forging is machined off and sold as scrap.

There are several reasons why automation of mechanical processes in factories must continue to develop and increase. Firstly, to meet competition, reduce costs and expand output. The companies in each industry that can reduce costs, and at the same time increase their output, will gain a tremendous advantage over their competitors. Secondly, there is a shortage of most types of skilled and semi-skilled labour, and if the increased programmes forecast by the large automobile manufacturers in the next few years are to be implemented, automation is the answer. It may be argued by the Trades Unions that automation will inevitably lead to unemployment. This has not proved the case in instances where transfer machines and other forms of automation have been installed. The operatives have been transferred to other work enabling increased output to be achieved and a larger share of world markets to be obtained.

With some notable exceptions, it would appear that cutting speeds and feeds at present in use do not show any marked increase over those common during the past twenty years. Indeed, there does seem to have been a tendency for some reduction here and there to conserve tool life, always provided the unit cycle time of the line is not exceeded. It is often found on analysing a job that the longest element of time is the handling and loading of the components into and out of the fixture, usually with considerable fatigue of the operator. It is to reduce this work element that we have turned to transfer machines, where the component is loaded and unloaded into the fixture once for some 20 to 30 operations and automatically progressed from operation to operation.

Thirdly, by obtaining increased output from the same floor space, new buildings will not be required, which with the present high building costs will result in considerable capital saving. In our own case we increased output from 3,500 to 5,000 vehicles per week in the same factory space, mainly by installing over 60 transfer machines, and some 150 rotary indexing type machines. It has also been possible to reduce our inventory by £2,000,000.

An automated machine line keeps work moving through the shops, reduces handling costs and eliminates banks of components between machines and once a transfer machine line is established and working to a predetermined and uniform time cycle, a regular number of finished components will be produced every working hour.

Design and Manufacture

It takes a long time to design and manufacture transfer machines and automatic machinery and in order to reduce the time required, we can either engage consultants specialising in this field to advise on automation methods, or we can approach companies engaged in the manufacture of automatic machinery. Alternatively, we can select from our own engineering staff, planning engineers, jig and tool draughtsmen and technicians and let them specialise in automation methods. It may take some time to

train an efficient organisation and having done so, someone else may attract them away, but this does seem the wisest course to pursue. Some mistakes will inevitably be made in the initial stages, but in the long run it will prove a wise investment and result in the formation of a group of experts who, having designed, proved and used the machines, are thoroughly familiar with their mechanism.

Problem of Breakdown

It will be argued that the more automation is introduced into the factory, the greater the risk of a breakdown in any one unit, stopping the whole production of the factory until the fault is repaired. This is undoubtedly true; mechanical breakages are inevitable and will occur but this should not be allowed to deter us from continuing with this development. Every effort must be made to make the machines as efficient as possible. The Americans claim efficiency figures of 75% to 80%; our own experience varies from 65% to 80%. Any vulnerable parts should be so designed that they can be replaced as quickly as possible. Spare parts must be kept available and the machine downtime thereby reduced to a minimum.

Electrical, hydraulic and mechanical parts should be standardised so that a minimum stock of spares is necessary. They should be designed for easy maintenance and interchangeability and skilled maintenance men should be specially trained in the maintenance of these machines.

Experience already gained in the design, manufacture and use of transfer and other types of automatic machines, and the lessons learned from the troubles which have from time to time been experienced are invaluable when considering the installation of further machines.

Although we have some machines performing with up to 31 stations, from a production and maintenance point of view it is considered advisable to limit the length of transfer machines to around 20 stations, primarily because in the event of a mechanical breakdown fewer operations are involved. One V8 cylinder block line equipped with cross transfer machines 350 feet long, is employing sectionised automation, i.e., there are five working sections of transfer machines each with their own separate driving ends; provision is made for banking a stock of monoblocs between each section so that in the event of a breakdown of one section, the other sections can go on working, drawing from the banked stock until the necessary repairs have been effected.

We have in use both platen type machines, i.e., where the jig and component are carried on a platen, and non-platen machines, where the jig and component are moved directly on the bed of the machine, and where it is possible to do so we advocate eliminating the platen, particularly where accurate boring operations are concerned. It also enables air operated pusher devices to be used for pushing the component into and out of the machine, thus making it completely automatic, and reduces considerably the cost of the machine by eliminating platens, loading and unloading ends, and platen return conveyors (Fig. 14).

When planning to use transfer machines for the production of new components, it is imperative that the tooling engineers are consulted by the designers early in the design stage of the component, so that any modifications that will make it more readily adaptable for machining on transfer machines can be adopted. Alterations at a later date after the machine has been built can prove very costly.

In planning for production of a new model, provided of course that the volume required is sufficient to justify the necessary capital expenditure, there are certain parts which are most suitable for manufacture on transfer machines, e.g., monoblocs, cylinder heads, gearboxes, rear axle cases, etc. All large quantity producers have adopted them for these components. Other parts can be more economically produced on special rotary indexing type machines, for a much lower capital cost.

There remain the parts which cannot at present

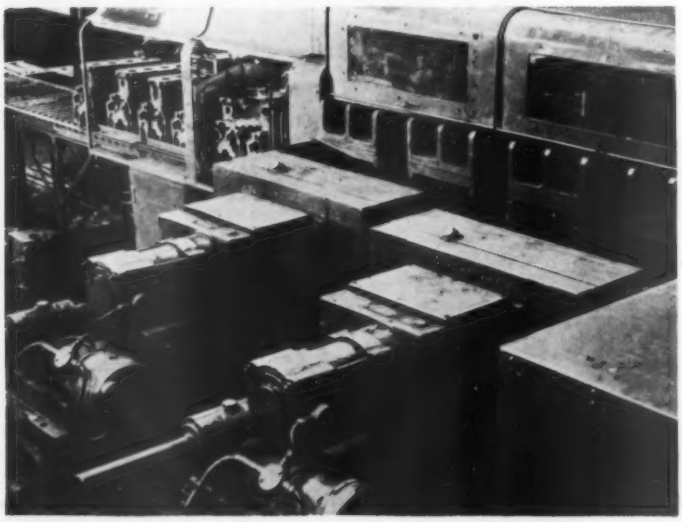


Fig. 14. Close-up of a fully automatic transfer machine for drilling oil gallery holes in monobloes, showing the pusher device for loading components into the machine.

be produced on transfer or rotary machines and which will continue to be manufactured on existing machines. These will have to be dealt with by introducing automatic means of loading into, and transferring the component from, one machine to another. This can be achieved if we have the co-operation of the machine tool and conveyor manufacturers, with our own engineers specially trained in automation methods.

There will be people who say that the Automatic Factory is not a practical proposition due to its greater complexity, resulting in more frequent breakdowns, which, when they occur, often stop the entire manufacturing process. This can largely be overcome by good design and efficient maintenance of machines and tooling.

The answer may be "Partial Automation"; that is, only portions of production will be automated. Generally, this applies to those operations where manufacturing costs are high and definite benefits will result, or processes where it replaces labour used to perform heavy, arduous and sometimes even dangerous functions, involving considerable operator fatigue.

Automation, however, whether partially or fully applied, must be right. The overall results if properly and intelligently applied are lower costs, elimination of operator fatigue, greater safety, balanced and increased production, uniform and controlled quality and reduced stocks.

It is up to those who are responsible for the management and engineering side to see that their companies do not lag behind in this new science, which is already firmly established. If they manufacture products in large quantities by continuous or straight line production methods, then they ought to be thinking and planning ways and means of applying automation to these production lines, if they are to remain competitive.

Acknowledgments

The Author wishes to thank the following for their courtesy in permitting reproduction of certain illustrations in this Paper :-

ALFRED HERBERT, LIMITED.
JOSEPH LUCAS, LIMITED.
THE AUSTIN MOTOR COMPANY, LIMITED.

MARGATE CONFERENCE

DISCUSSION GROUP 1B

AUTOMATION—
SOME PROBLEMS FOR THE MANAGER

by F. GARNER, M.I.Mech.E.

Mr. Garner

After serving an apprenticeship with Rolls-Royce, Limited, in their works and drawing offices, Mr. Garner gained experience in heavy engineering with W. H. Allen, Limited, of Bedford, manufacturers of diesel engines, steam turbines, pumps and electrical machinery.

He joined the staff of Imperial Chemical Industries, Limited, shortly after its formation and served overseas on heavy chemical engineering. Upon returning to England, Mr. Garner became an industrial consulting engineer and subsequently joined the staff of his present employers, Joseph Lucas, Limited.

AUTOMATION is used in industry, commerce, communications and agriculture. It is being employed on an increasing scale for military products. The experimental use of an electronic brain in weather forecasting is also being tried. There are many vitally important uses of automation that are incorporated in the finished products of industry. For example, but for the employment of automatic control devices the aircraft gas turbine engine of today would not be possible. Management problems

relating to automation arise in all spheres of work, but this non-technical discussion paper is largely confined to the management problems of automation in industry, and particularly manufacture. Industrial managers have much experience of automation and its difficulties in public utilities, and in the mining, oil, chemical, food processing, bottling, canning, and packaging businesses. The manufacturers of products such as motor cars and wireless sets are also very experienced in this field.

In the majority of British industrial concerns, however, automation has not yet been established on anything like the fullest scale that would be sensible. There are some organisations where scarcely a beginning has been made. All such shortcomings are the direct responsibility of management. Failure may be due to a variety of reasons but they all come back to inadequate management, whether the excuse be an unsympathetic board of directors, unsympathetic labour, absence of necessary engineering capacity or lack of money. Nearly always the failure on the part of management is due to insufficient understanding of what is meant by automation and what advantages it has to offer. Without a clear understanding of these points, the executive is unable to provide the all-important inspiration and training needed by those below. Where this weakness exists, the first automation problem is for management itself to become better informed before trying to proceed to the general problems of application. Except, therefore, in the few undertakings where automation is already established on a large scale, or where a manager is already well informed on the subject, the problem should be studied in three stages :—

1. What is automation ?
2. What are the advantages of automation ?
3. What are the problems for the manager in applying automation ?

Production engineers may regard this three-stage approach as unnecessary for management and suggest that only the third and last stage need be considered. But production engineers need to remember that, whilst they themselves are generally well informed on the first two stages and equally knowledgeable on the technological and the technical problems, they cannot be expected to be anything like so clear on the executive problems of the third stage. As managers are not always drawn from the ranks of production engineers, and may not possess any engineering background, some executives may be weak on the first two stages. A clear, broad knowledge of the first two stages is essential for every manager before he proceeds to Stage 3 and tackles the management problems associated with the application of automation. This discussion paper goes on to deal in turn with each of these three stages.

Stage 1—What is Automation ?

Automation is a recently coined word that comes from America and is so new that it does not appear in the dictionaries ordinarily available. The source of the word itself is not clear. Some Americans say that automation is a simplification of the word automatisation. Others say that automatic control and instrumentation have been joined to coin this new word. Opinions also differ as to the meaning of the word. There are those who believe that automation is confined to transfer machines and electronics. Others regard automation as meaning simply the mechanisation of work processes. When the Ford Motor Company of America did their pioneer work on the automatic loading and unloading of machines, they named their new technique "automation." Since then the meaning of the word has been widened to include partial and practically fully automatic control in commerce, communications and industry. This tendency to widen the scope of the word is likely to continue. For many managers in industry it may be best to regard automation as the natural development of mechanisation, sometimes supplemented by advanced instrumentation and applications of hydraulics, pneumatics and electronics.

Automation must not be confused with automaton. Although there is but the difference of one small "i" in the spelling of the two words, they have entirely different meanings. The dictionary defines automaton as—"Living being whose actions are involuntary or without active intelligence ; living being viewed materially." This definition was ably demonstrated by Charlie Chaplin in his film "Modern Times." In this comedy he lived in a nightmare in which he was manually tightening bolts. Fully developed automation would have tightened the bolts without him and he would not have been there. This is a simple illustration of the difference between the two words. Another and quite different example is the loading of ships with coal by means of a human chain of carriers, using baskets, compared with conveyor loading.

When the term automation is applied to any device in industry that saves drudgery, or reduces risk to health, life and limb, or saves any form of human work, a new word is being used for something that has been practised and consistently developed since the Neolithic period when man first sought to live a settled existence. Two of the earliest, most elementary, and most outstanding examples are the wheel and irrigation. It is believed that the burdens of man were first relieved by the use of crude wheels in the days of the New Stone Age some ten to twelve thousand years ago. Irrigation and water storage by damming, in place of manually lifting and carrying water in skins, were first used, so the archaeologists say, in Jericho, the oldest known city in the world, perhaps as far back as 5,000 B.C.

Agriculture provides a good example of the blessings brought to mankind by elementary mechanisation, which has now often grown almost to full scale automation. Without this progress the world population of today could not live. Over the centuries starting long before the industrial era, the drudgery involved in the growing and preparing of food has been steadily reduced, and productivity has been raised, by mechanised progress in ploughing, sowing, crop gathering, threshing and milling.

Industry has also made continuous strides in reducing human work through mechanisation. The cotton and the woollen mills provide important early exam-

ples of progress. Boot and shoe manufacture is another. The present stage of automation in industry is a logical development made possible only by this continuous progress in mechanisation over many years. At the simple end of the scale there is, for example, the small, cheap automatic or semi-automatic chute or attachment for loading or unloading a machine. At the other end there seems to be in sight the almost completely automatic factory, but there will be relatively very few of these. In the chemical and oil refining industries, automation has been applied to continuous processing and instrumentation to the point where the products are scarcely visible in the making and certainly not manually handled at any stage. Powdered materials as heavy as lead can be conveyed in pipelines by low pressure air. Automation is applied to the loading, transportation and unloading of all kinds of goods, not forgetting the radio controlled factory truck operating without a driver. A mechanical hand is able to duplicate any motion of the human arm and hand, pick up as much as 750 lb. with the one hand and yet handle a tea cup with what is described as a "dowager's finesse." "Drop forging" can be done completely automatically without sweat or manual skill in the actual operation. Assembly machines are available that incorporate automatic units for metal spraying, machining, riveting, stud placing and driving, welding, testing, etc. As a rule, major components are placed manually in these machines, but in a few they are placed automatically.

No reference to automation would be complete without mention of multiple continuous machining, to which much glamour is often attached. One of the latest examples is an American machine described as "an automated engine line," but more generally known as a transfer machine, which handles 50 engine blocks per hour, is 1,100 feet long, performs 385 operations, carries out 200 inspections, automatically rejects faulty work, is made up of 133 automatic units arranged in 14 electronically-controlled groups and costs $22 million. Comprehensive transfer machines of this type are comparatively rare, but there many thousands of automatic and semi-automatic standard and special purpose machines catering for the needs of almost every class of industry. In commerce, automation covers a wide range from electronic computors to copying machines. In communications, automatic telephoning has for many years been able to make use of an electronic device that finds an alternative route when the direct line is busy. Automation is also used in communications to record by code for charging purposes the date and time of a telephone call, the subscriber's number, the number called, the duration of the call, and the cost. The technical discussion papers will have shown in more specific detail the many ways in which automation is used today in industry, commerce and communications.

From all that has been said, it will be seen that managements must first be clear that, although automation is an entirely new word, the technique is a natural development of the mechanisation that has made continuous progress since the start of the industrial era. Management should not, therefore, look upon automation as some entirely new trick, tool or animal that can be used to provide magic solutions to industrial problems—especially those of management. And since the technique is not so new after all, management should not be deterred from applying automation to the fullest sensible extent because they are shy of a new word. Additionally, if a manager has found this story of what is meant by automation at all helpful, he should realise that it may be of greater help to his staff of all grades. In that event, he should preach the story as his first gospel in beginning to win their support and enthusiasm for automation.

Stage 2—What are the advantages of Automation?

Depending upon the nature of the work and the particular application, automation can be expected to provide one or more, and sometimes all, of the following advantages within a factory :—

(a) improved working conditions ;
(b) improved product quality ;
(c) improved productivity ;
(d) improved output ;
(e) improved economics.

(a) *Improved working conditions* for production operators often result from automation. The benefits may take the form of reducing demands for physical strength, dexterity and mental aptitude. There may be less drudgery. An improvement may take the form of remote power handling instead of close manual handling, or result in fewer people being required, so that there is less risk to life and limb. An operation or process dangerous to general health may be radically changed so that no labour, or less labour, or more remote labour, is employed. Automation may be initiated solely to meet the need for improved working conditions for labour on particularly hazardous, hard or unpleasant work, and any other gains would then be incidental. Opportunities for automation to improve working conditions for labour occur, for example, in mining, chemical processes, handling raw materials, construction work, stoking, forging, smelting, heat treatment, dusty work including shot and sand blasting, mixing heavy materials, sheet metal work, machining, lifting, assembly, handling of machine tool swarf and transport. These are but a few of many possibilities.

(b) *Improved product quality* is frequently sought and obtained in some industries through automatic processing, control and instrumentation. All machine tools provide some degree of automation, even though it may take only the elementary form of a centre lathe lead screw. Without such machines, the shaping of metal to required dimensional and geometrical tolerances by ordinary people would not be possible. Interchangeability of parts and volume production would also be unknown. In general, the more automatic a machine can be made the greater the degree of uniformity of the product. Machines for other purposes may also be expected to produce uniformity if they are made fully automatic in operation. Programme electric welding with the closing

of one switch is an important example where, in order to obtain a reliable joint, there is a completely automatically timed sequence of operations. There are many manufacturing processes that are so complicated or laborious when performed manually that it is a mental or physical impossibility for an operator to turn out consistently acceptable work, so that automation—full or partial—may be the only real solution of the problem. In gauging and testing work automation is sometimes more reliable than manual inspection.

(c) *Improved productivity* is generally expected from automation, and many people look on automation as almost wholly a means of raising productivity. No matter how able and willing an operator may be, he or she can very rarely compete with effective automatic operation. This applies to all stages of work whether it be loading a machine, carrying out the particular operation, or unloading. Automation can often be the greatest single factor in raising the productivity of men, materials and manufacturing facilities. Occasionally automation can have a greater influence in raising productivity than all other factors combined. In industry as a whole, improved automation, in the widest possible sense of the word, could do more than anything else to raise productivity.

(d) *Improved output* is nearly always possible from automation and is generally expected and needed.

(e) *Improved economics* must almost inevitably result from increased automation. The degree of the improvement will depend upon the extent to which automation has improved working conditions, product quality, productivity and output. A further factor in some industries may be product design economies made necessary by, or inspired by, automation.

The extent to which any or all of the foregoing advantages are secured may have an important bearing on the present and future standing of a particular company. Its sales volume and income may be increased through lower costs and correspondingly lower prices, or through better quality, or both. The immediate economic position of the organisation may be improved. The general well-being of all grades of employees from the managing director down to the most humble junior may be improved. Perhaps most important of all, the company may take a step forward in providing for the successful continuity of the business. If the manager has found this story of the advantages of automation of interest and value, he should preach it as his second gospel in getting the goodwill of all grades of his staff for automation.

Stage 3—What are the problems for the manager in applying Automation ?

With a clear idea of what is meant by automation in manufacturing industry and what it has to offer, management is well qualified to consider the third and final stage, that is, the problems likely to arise in the application of automation. Difficulties vary in character and intensity, not only in different branches of industry but also in businesses of the same type. In a business where automation has progressed steadily and reached a high level of development, management problems are often relatively simple since the whole organisation will have grown up with, and adapted itself to, such techniques. The few problems remaining or recurring will be well understood and management will have little difficulty in dealing with them effectively. But the number of such industrial undertakings with the most advanced automation will always be a small percentage of the whole. Whilst practically all industries can profit by automation, the scope varies widely with the nature and size of the business. Complex automation is worth while for some industries, whilst for others very elementary equipment will suffice.

The major problems of automation likely to arise for the manager in a particular industry or factory can usually be placed under several of the following summarised headings :—

(a) the manager himself ;
(b) planning automation ;
(c) cost and financial return ;
(d) people on the staff ;
(e) staff training ;
(f) engineering staff and skilled men ;
(g) production engineer ;
(h) production engineering staff ;
(i) product designer ;
(j) product design staff ;
(k) supervision ;
(l) skilled labour ;
(m) productive labour ;
(n) team working ;
(o) development facilities ;
(p) overhead charges ;
(q) outside suppliers.

These items are now considered individually :—

(a) The Manager Himself

A manager is not likely to be working in an undertaking, or to join a company as a new broom, where no measure of automation, however simple, has yet been applied. But there may be occasions when automation is to be considered seriously for the first time, or is to be developed on a much more comprehensive or accelerated scale than before. The problems arising on such occasions will naturally be more pronounced as a rule than those in a manufacturing organisation where automation has been continuously applied over a number of years. In addition there might be special preliminary difficulties. The first might be with the manager himself wavering because his particular business was "different." There are very few factories where the products, and engineering knowledge, are such that nearly complete automation can be applied at one fell swoop, or even over a long period. There are, indeed, relatively few manufacturing undertakings where full, or nearly full, automation could ever be applied in the forseeable future.

It is, therefore, important for the manager himself to be convinced that inability to apply full or extensive automation all at once does not justify him in sitting back and believing that nothing can be done.

He must have a strong personal belief in, and conviction of, the benefits of automation and in turn he will have to convince his management colleagues.

(b) Planning Automation

There are well organised and staffed manufacturing organisations where automation makes satisfactory and even rapid progress on a piecemeal basis. Improvements are thought out, designed, made, developed, brought into operation and consolidated separately, or in small numbers, before work on the next project, or small group of projects, is started. This can be a safe procedure in some types of business and more effective than it appears at first sight. But in many concerns this happy state of affairs does not exist and cannot be built up overnight even if the nature of the processes carried on is such that it might be developed in time. Other companies, because of their processes and other circumstances, may be organised and staffed so as to be able to apply increased automation on a large scale at intervals of a few years. In this case a complete survey might be made, say, this year, of the scope for further automation and perhaps also other major reorganisation at the same time. Plans would be settled and the work would go forward so that during a major shut-down in, say, one or perhaps two years' time, new equipment could be installed and the whole place completely or largely reorganised. This would be followed by a period of full output, during which there would be no further substantial changes in automation or other conditions. This cycle might be repeated every few years.

In a small number of industrial undertakings the products are such that both schemes can be operated simultaneously, that is, there are both continual piecemeal additions to automation and also a major reorganisation, including a big advance in automation, at intervals of four or five years or more. For the manager who would like to more forward to far better advantage than before along one of these two paths of progress, or perhaps along both simultaneously if processes, etc., permitted, the first problem might arise in knowing how best to make a start. Here he could not do better than find someone—perhaps himself in a small organisation—capable of making a partial or full survey of the likely scope. For this there are six broad possible approaches: (1) to use suitable existing engineering staff; (2) to train existing staff; (3) to recruit suitable staff; (4) to engage outside specialist suppliers; (5) to engage consulting engineers; and, lastly, a combination of any or all of the first five possibilities. A full or partial survey should then follow.

Depending upon the nature of the business, the survey might start with, or quickly come to, a study of product designs to suit automation. In any event, a detailed study of the manufacturing operations or processes would be necessary on the floor of the shop. From the survey an estimate of the cost of the proposed automation programme could be prepared. Against this estimated expenditure could be set the expected return from improvements in working conditions, product quality, productivity, output and production costs. A recommended programme of automation could then be prepared for approval and execution. The required equipment might be designed and be made by outside suppliers. On the other hand, the manager might find it desirable to design his own equipment and have it made by outside contractors. If either design or manufacture of the equipment or both were to be undertaken within the organisation, an allocation of existing or new staff to that work would be necessary.

(c) Cost and Financial Return

Correctly applied automation is almost certain to provide an adequate financial return and is sometimes the most remunerative investment possible. The rate of return will vary widely according to the nature of the work, and on this count the manager may experience some difficulty. There will be exceptional examples where the expenditure on a single item of automation equipment can be recovered in a matter of a few weeks or months. An average of around three years could be expected in many larger installations. There might, however, be a combination of exceptional circumstances that would justify recovery on a particular project over the comparatively long period of, say, ten years. There may be applications of automation without any direct financial return on the outlay that are, nevertheless, justified, because the indirect return is high and in fact makes possible the maintenance or expansion of the business as a whole. Such applications fall into one of two classes: (1) for productive labour reasons, and (2) for product quality reasons.

It has already been explained that, in very special cases, it might be necessary, or worth while, to provide automation in order to reduce risk to life, limb or general health of the operators, without regard to direct financial saving, although in all known instances the additional advantage of cost reduction has also been obtained. In view of the labour shortage now prevailing, it may also be necessary in some industries and some districts to install automation equipment without insisting on the normal standard of direct financial return in order to improve working conditions and so make possible the retention or recruitment of productive labour. In an extreme example of this sort, lack of automation could mean no labour and therefore no business. Shortcomings in the quality of the product when the established production methods are used for a particular process may make it essential to find some way of improving quality in order to maintain the company's good name. Automation has sometimes provided the right answer; there may have been no apparent direct financial return on the investment, but on the other hand the change may have made possible the survival of the business or made the particular product a success instead of a failure. Taking this still further, it is conceivable that on a new and highly specialised product automation might be the only means of making a business possible.

Automation may become doubly attractive financially, and therefore less of a problem for a manager

with his Board, when it is introduced to meet a rise, or anticipated rise, in the demand for output. In such an event the resulting increase in productivity of people, plant and buildings from automation can often lead to a substantial saving on the net capital investment that would otherwise be required for a proportionate increase in facilities of the existing type to meet the need for greater output. The capital saving might be made up of savings on both plant and buildings. In addition there would probably be substantial economies on the total service charges as a result of the lower floor space occupied, the smaller number of machines, etc.

(d) People on the Staff

Whatever the conditions, whether the approach is entirely new, or an acceleration, or extension of scope, or continuous steady progress, the most important constant problem of automation for a manager is nearly always one relating to people. This is not a problem merely with one particular grade of people, but with nearly all grades in the organisation and maybe with some people outside as well. Staff within the organisation includes directors, supervision, personnel staff, production operators, quality staff, product designers, production engineers and skilled craftsmen. With automation being adopted on a big scale, the financial and commercial staffs too might be involved. Outside the organisation, trade union officials might have to be dealt with as well as the factory inspector, and the staffs of automation equipment manufacturers. Success in automation, as in nearly all technical progress in factories, must depend almost wholly upon the way in which the members of the staff are handled. It is here that a thoroughgoing knowledge of Stages 1 and 2, i.e., what automation is and what it has to offer, is invaluable to a manager in dealing with the various groups of his staff. All must be informed, encouraged, guided and made strong believers. Training can be very important. A manager can sometimes promote happy and effective working by seeking advice on an automation problem from members of his staff.

The general manager or works manager or production manager responsible for automation could not expect to get full support from his management colleagues if they were kept ill-informed. This might be serious, especially with, say, the chief engineer in getting designs altered to suit automation—or with the personnel manager in labour difficulties—or in getting the commercial manager to accept modified products—or in getting financial support from the chief accountant. Directors always have to be told what is good and be shown the best way to go, otherwise schemes might not be approved, including those for automation. Production supervision is the backbone of the whole body on any factory floor. In the eyes of the weekly wage-earners, supervision are the company. Supervision are the only representatives of a company in constant touch with labour. If supervision are not convinced that automation is good and can be made to work well, it will not succeed to the fullest extent, since the maintenance staffs and operating labour will not get the required close support and encouragement. Time spent by the manager with supervision on such matters will be well spent. As production operators are nearly always the persons most directly concerned with automation and most likely to benefit from it, they should be suitably trained for the new conditions and be told what is going on, and their full co-operation should be sought. Even a good thing can be unpalatable if it is served up the wrong way. Product designers may have to revise their designs to suit automation. If they know what is going on and are in the team, they will be more enthusiastic and much more likely to produce the required modifications. It is of the first importance to give recognition and encouragement to production engineers, or any other specialist engineers, responsible for automation, as they are often the technological key to success. The results as a whole will certainly benefit if the thinking behind an automation project is explained to the skilled craftsmen who make and maintain automation equipment, and they are told what is expected. In some instances, it may be desirable to consult the safety engineer.

The design stage of an automation project may cause concern to a manager when the design staff are not really interested and doubt whether the scheme will work. But a much more severely testing time for a manager may often occur during the development stage. The parts may have been made and the assembly may not work. Here the manager must tread warily. He may not have the least technical idea of how to help in getting the equipment to function. Despite this, he must provide some sort of guidance, general inspiration and encouragement for those who are losing heart but have the best qualifications for achieving success.

Trade union officials are responsible and progressive people who often understand, and therefore support, automation in industry. They should be consulted in all appropriate cases where labour principles are likely to be involved and where the interests of particular members of their unions are likely to be affected materially. Members of the staffs of outside concerns supplying automation equipment will work to better advantage if they are given clear instructions about what is required. Sometimes discussion with these outside people will be beneficial and, in fact, necessary before a specification of requirements can be prepared. The possibility of help from Government Departments should be kept in mind, and this applies especially to the Factory Inspector. As the correct handling of people by management can often be so vital in automation work, the major difficulties likely to arise with some groups and department heads are later dealt with in greater detail for each of these groups and departmental heads separately.

In this problem of people, a manager must always bear in mind that he is but one man and by himself can do but little. To get the best results he may spend one hour on making up his mind on a problem of automation and ten hours in talking to people and getting their good will and co-operation with a view to its early and effective adoption.

(e) Staff Training

If automation is to be applied on a worth-while scale and at an acceptable rate, the training of people is often of the first importance in any organisation other than a very small one. Many managements understand this and are willing and able to prepare and operate training schemes to suit the needs of particular groups. Occasionally, however, the manager himself may be the greatest single stumbling block to progress and in that case training should start with him. His first step should be to study Stages 1 and 2, already discussed, that is, what is meant by automation and what advantages it has to offer. After that, he can proceed to a study of automation in other factories at home engaged in his own or a similar business. To see automation at work in entirely different industries would widen his knowledge and experience. At a later stage, a study of automation in the widest possible manner in suitable foreign countries might be worth while. The studying of appropriate technical books and journals, and visits to automation equipment makers, would be beneficial. Production engineers, product designers, supervision, and as many others as possible who may be directly concerned, should also be encouraged to study both within and outside their own class of business. As with the manager, it is always worth while to let these people broaden their outlook and experience by seeing what is being done in both allied and entirely different fields of manufacture and after close and wide study at home it may be well worth while for some of them to go abroad. The manager must learn that it is not sufficient for him alone to travel, visit and see. The production engineer and others concerned must also be given the opportunity of seeing the light. It is one thing to believe and act through being told but without seeing, and quite another to believe and act after seeing. In all this educational work the production engineer, or his equivalent, should have two broad aims : (a) to get general inspiration, and (b) to study technical features on the floor of the shop. The product designer, or his equivalent, should also have two broad aims : (a) as with the production engineer, to get general inspiration, and (b) to study product design for automation. All who make these special studies and travels should combine in preparing training programmes for the less fortunate, and especially for juniors. Such educational courses might cover lectures, films, demonstrations and limited factory, exhibition and other visits. Included in these programmes would be junior production and design engineers and supervision. Specially prepared facilities should also be provided to enable skilled mechanics and production operators who are directly interested to obtain information. Technical members of staff should certainly be encouraged to read suitable technical books and journals, and also to attend worth-while lectures and visit appropriate exhibitions and automation equipment makers.

(f) Engineering Staff and Skilled Men

The manager must accept the principle that, in most undertakings, the more he wishes to improve conditions for the direct operators by further automation the greater will be the burden on his engineering staff and skilled men. This is inevitable when the equipment has to be designed or made within the organisation, and plans must be laid to increase the strength of engineering and skilled men as required. This problem is discussed under detailed headings that follow.

(g) Production Engineer

Depending upon the type of business, the technical spearhead of the attack on automation may be furnished by mechanical engineers, hydraulic engineers, pneumatic engineers, electrical engineers, electronic engineers, chemical engineers or chemists. But in the vast majority of manufacturing industries, senior production engineers are the key people. Technically they investigate, initiate, expose problems, and carry through the main tasks. It can be a serious problem for a manager to find or develop a chief engineer with a flair for automation. A first-class knowledge of tool design, or machine tool design, or metal shaping operations, or welding, or finishing operations, or assembly, etc., does not by itself guarantee that the engineer will be equally first-class in the general application of automation.

The most essential thing for a successful engineer on automation is to have a distinct flair for, and therefore interest in, such work. A chief production engineer with a pronounced flair and interest, but with only a moderate standing as a production engineer, will always be more successful in automation work than a chief production engineer of narrow outlook but much higher standing on, say, machining techniques, presswork and assembly. The assistance of a highly specialised engineer in any particular process can always be readily found once the scope for automation has been seen and a general idea formed.

Chief and senior production engineers can cause anxiety to management in diametrically opposed ways. First, there is the otherwise basically sound engineer who is rigidly set against any progress that smacks of automation. As an example, there is the engineer who prefers, irrespective of quantities and other circumstances, the "security" of a lot of little presses and separate tools for a particular pressed component, and dislikes having all his eggs in the one basket of a single transfer press or near equivalent. He is inclined to argue on differences in tool costs only, based on opinion, instead of total cost estimate comparisons, and to ignore all other factors such as floor space, number of presses, production control, work movement, etc. The second type of production engineer does much less harm. He has a progressive outlook, a dissatisfied mind and a critical cast in his eye and wants to apply automation to everything irrespective of practicability and economics. Properly guided, he can be a great force for progress. The manager must learn to sort out the wheat from the chaff of such an engineer's ideas without killing his enthusiasm. If a manager has to choose between the two types, he should come down heavily in favour of the "progres-

sive" engineer and then hold him in rein as closely as may be necessary, but still lightly.

When product design plays an important part in automation, the manager must see that the production engineer works patiently and easily with the product designer. This is not always a simple matter. The engineer must be made to realise that he often enjoys many advantages which are not equally available to the designer. The work of the production engineer broadens his outlook and experience, since he deals every day with people of wide interests throughout the organisation. In particular, he often derives great benefit from being in constant touch with management and therefore more at the centre of affairs and more fully informed. Especially is the engineer expected to have a greater appreciation of time and money than the designer and the benefits of automation have to be judged largely by the results in terms of time and money.

The most able manager will have no salary problem in regard to his chief production engineer. For the particular work in hand, he will find the best man on orthodox production engineering and automation and with ability to work with others, and willingly pay the market value salary, knowing full well that the engineer who can command, and is worth, twice the salary of another often has ten times the capacity for original thought and breaking new ground. The manager will also realise that no number of mediocre men, though costing in total much more, can together provide the ability of a single first-class production engineer, well suited to the particular need.

(h) Production Engineering Staff

In some industries and individual undertakings, the management problem in regard to production engineering staff can be as great as that in respect of the chief engineer himself. The total technological knowledge required for extensive automation is nearly always much more wide and deep than that needed for plain, straightforward production engineering. This may mean bigger and better staffs covering fields such as process planning, tool design, work handling, factory layouts and the selection of the most suitable standard or specialised machines and equipment from outside suppliers. In his anxiety to do the best on a day to day basis the chief production engineer may be inclined to struggle on, regardless of need, with the staff he has and he may then become worried and unimaginative and believe that nothing can be done to improve the position. He may be so anxious that he is unable to sit back quietly and assess his needs and then take action to get them met. It is here that the manager must lend a powerful helping hand and see that the chief production engineer sits down and thinks out his needs in an objective fashion and is then helped to get them fulfilled. To encourage the necessary thinking and action on the part of the engineer, the manager may need to adopt a question and answer technique : "How many assistant engineers have you? How many do you need ? Why can't you get the additional ones you need ? Is it a salary problem ?" and so on.

The manager who wants the best results will not be deterred by salary considerations from recruiting the best in quality up to the required quantity of production engineering staff. It is good business to do this, as a few men of the required capacity can go many times further than a host of men of limited capacity.

(i) Product Designer

The production engineer is not always the chief architect of progress in automation. In some industries this role is played by the chief product designer, and then the manager may have a more trying problem with the product designer than he has with the production engineer when he is the key man. The importance of the product designer may be paramount where the fullest measure of automation is required, but cannot be secured without new designs or fundamental modifications to the existing ones. Product designs that are sound and acceptable for production by ordinary methods are sometimes entirely unsuited for automation. Inability to provide the required design modifications has sometimes caused more delay than all other factors combined. The fact that the product designer is isolated may be the main cause of delay, and especially so when the individual is well qualified in the technological sense in regard to the product and its functioning. He may be quite unable to make an entirely new and perhaps unorthodox approach, or to relax what he regards as fundamental design principles, or even to modify dimensional tolerances, to suit the needs of automation. If he is kept in the narrow confines of the design office or the laboratory, he cannot be expected to have a real interest in time and money or to understand the commercial and economic demands on the undertaking.

The remedy for all this is for the manager to bring the chief product designer fully into the executive team from the start, so that he will appreciate other aspects of the business better as well as his own part. This will lead to a more balanced outlook and greater co-operation without any sacrificing of the necessary performance and reliability of the product. The manager may find the going somewhat hard at times but he must be patient and not look upon the product designer as long-haired and tiresome, and the prima donna of industry. Managements in some industries must remember that their product designer is the most important individual in the organisation, in that if he fails there will be no business for the management to operate.

A product designer is not always involved. Some products, for example those of the chemical industry, are controlled by specifications and processes laid down by chemists, and the chemist then exerts an all-important influence on the scope for automation. Some of the most outstanding progress in automation has been made in industries of this kind and to chemists must often go the main credit. But when the chemist is isolated and therefore not well suited to apply new and clear thinking, he can be the greatest power for stagnation in regard to the

automation of processes. Here again, as with the product designer, the manager must bring into the team from the start a chemist who will be co-operative, imaginative, and clear-thinking in modifying specifications and processes to suit automation without sacrificing essential product quality. No question of salary limitation should be allowed to deter a manager from recruiting the best man for the job, be he product designer or chemist.

(j) Product Design Staff

The manager's problem in dealing with staff shortcomings of the product design department, both in quality and quantity, is substantially the same as for production engineering staff and, in the case of staff shortages, the manager should apply the catechism treatment in the same way to his chief product designer. There are some businesses where a handful of able design assistants can work almost miracles in providing product designs to suit extensive automation. In other businesses, a small but able staff of chemists can do likewise by their work on specifications and processes. The wise manager in either case must decide that he can afford to have only the most suitable people for the work in hand and pay the required salaries with a smile, knowing full well that it is, again, good business.

(k) Supervision

Above all things, a manager must see that the opinions of supervision are properly valued. Once a piece of automation equipment is on the way to being satisfactorily established, the manager can avoid difficulty with supervision by seeing that they are invited at the earliest moment to see the new rabbit emerge from the hat and give their opinions. Whenever practicable, this first viewing should be in a development shop before the equipment reaches the production factory. It can mean a serious setback to the management's plans if a new device is thrust at the last moment upon supervision who have been kept in the dark. This invites the attitude of: "That's not a bit of good on my class of work." Early inspection of the innovation by supervision gives them an opportunity of "putting it right" before actual production and taking it under their wing as their own rabbit and seeing that it prospers.

(l) Skilled Labour

Although, as already stated, automation eases the burden of production operators, it is the reverse for those skilled machinists, fitters, electricians, testers, etc., who manufacture, develop and maintain the automation equipment, which may vary from the most simple to the very complex. The problem here is for the manager to see that adequate and able skilled staff is recruited, trained as necessary in the specialised work, and encouraged in every way. Sometimes this load can be eased by designing equipment within the organisation and getting it made by outside contractors, leaving only maintenance to the resident skilled staff.

(m) Productive Labour

For the reasons already stated, productive labour will generally welcome automation and especially is this so when management makes a point of giving full information at an early stage. In most progressive industries no technological unemployment arises from the introduction of automation on a modest or even a full scale. There is often a simple explanation for this. Automation nearly always increases productivity. Increased productivity lowers costs and selling prices. Lower selling prices increase the sales demand. Increased sales demand may keep pace with, or be outpaced by, increased productivity, so that the same total labour, or more, is required. The improvement of product quality through automation can have the same stimulating effect on sales. Examples of industries where automation has increased productivity and at the same time increased total employment are the motor car and the wireless industries.

All of this is not to say that managers will always be free from productive labour problems with the introduction of automation. If the new equipment does not work as reliably as the old, operators will become disheartened and rightly complain. Such unreliability may also affect earnings adversely and again labour will be right to complain. A much more serious problem for a manager can be the grievance of labour operating old equipment under trying conditions of sweat and risk, alongside new facilities with greater automation and much pleasanter conditions. The grievance will be further aggravated if the workers on the new plant earn higher wages than those on the old. Should this difficulty of the old and the new arise, the only permanent remedy is to provide the latest and best facilities for all.

After labour has seen the advantages of increased automation and realised that there is no fear of unemployment, the greatest labour problem for the manager may still remain. This is one of earnings. One operator does not expect to be singled out for a special wage increase because his particular work happens to be transferred from an old machine to a new one with increased automation. Neither would a small group. Such treatment would be regarded unfavourably by the many others who were not lucky enough to have the new facilities. But if a factory as a whole substantially improved its productivity and economics through increased automation, the labour force as a whole would expect some share in the larger return, even though their effort was less and their working conditions generally more acceptable. Improvement in some form would be inevitable for people on the payroll as a whole but they should not expect, and could not be allowed, to take all the gain. As always, the customer, the buyer of the wireless set or motor car, would expect and should be given some of it. In this way an employee might reap a double reward—higher earnings from making the wireless set and a lower price when buying it. The problem for the manager would be to settle how much of the total gain through automation should go to the employees, how much to the cus-

tomers if sales are to thrive, and how much should be ploughed back to help provide for the successful continuity of the business.

Reference was made to the need for supervision to be allowed to see the new automation equipment at the earliest possible moment. Almost invariably it will be good business to take the production and maintenance staff concerned into the development shop to see the new equipment, whether their number be one or fifty. It is a further advantage if these people are allowed to operate the new equipment in the development shop and give their opinions, which, coming from the people most close to the job, are nearly always valuable.

(n) Team Working

The importance has been stressed of keeping people informed and getting them to work together if the best results are to be achieved with automation. In a small organisation this may not be very difficult as only a few members of the staff will be directly concerned. Whether the size of the organisation be great, medium or small, it is essential for the manager to depend primarily for success in automation upon the capacity of individuals and personal responsibility rather than a soulless committee. But as a business grows and the variety of products expands, the manager will find the successful coordination of all efforts more difficult. He may then find it necessary to appoint a working team, able to work part time in the design office and part time on the floor of the shop, as distinct from a sitting committee, to handle automation problems. The manager himself might be the leader of the team with the product designer, production engineer, works superintendent and quality engineer as team members. Additional members from the costing, time study and personnel departments, etc., would be co-opted as necessary for special problems. With further expansion a separate automation team might be desirable for each product. With this arrangement it might be found possible to make the works manager or factory superintendent of the particular product the team leader. The other members of the team would be the chief designer, chief production engineer, and chief inspector of the particular product. Specialists would be co-opted as required. An alternative to a separate team dealing solely with the scope for automation in the manufacture of each product, is to have a separate team with comprehensive responsibility for each product. The make-up of each team would be the same as in the previous example and, with these wide interests, it would be mainly occupied in investigating all ways and means of improving working conditions, product quality, productivity, output and economics, since these factors largely add up to the success or failure of a business as a whole. But all of these are the same items as those already listed as the advantages of automation. The teams would therefore, amongst their other activities, encourage the use of automation wherever it could be applied with any of the listed advantages. Teams would obtain specialist help as required. Successful examples of this latter method of team working are in operation. Properly organised, such an arrangement can greatly reduce the automation and other problems of a manager and lead to better results.

(o) Development Facilities

Many managers have a problem of not knowing how best to develop their automation equipment so that is it reliable enough for production use. This difficulty can arise both with bought-out units obtained from outside suppliers and with units developed within the organisation. Where practicable, a development shop away from the production departments should be provided for trying out extensive or involved new facilities. In all suitable cases a full scale try-out should be arranged with engineers, supervision, maintenance staff and operators all present and working as may be required. This can be very important in some classes of work where conditions in the production shop are not conducive to long, patient, development work and where many set-backs are likely to be experienced. The pushing of new automation equipment into production without thoroughgoing development and trial can lead to heavy unnecessary expense through excessive maintenance requirements, and loss of output caused by breakdowns.

(p) Overhead Charges

The manager who is most successful in making far-reaching applications of automation may create for himself a special problem of costing. In the past he may have expressed his overhead charges as a percentage of productive labour costs. When the cost of productive labour was a relatively high percentage of the total payroll and total cost, this method of costing was reasonable and acceptable. But if the productivity of productive labour is greatly raised through automation, that basis for calculating overhead charges tends to become unsuitable and unreliable. For example, the number and cost of the skilled staff, including the maintenance staff, may become much higher than the figures for productive labour. In that event, the manager might have to deal with the problem of establishing a new cost procedure with the overhead charges expressed as so much per piece, or number of pieces, or gallon or yard or ton, etc., according to the product.

(q) Outside Suppliers

Some of the few highly specialised industries in Britain have long, successful experience in designing and making their own automation equipment on a comprehensive scale, and others purchase their complete equipment from very capable outside suppliers who concentrate on such needs. In both cases the managements are fortunate, for their problems are much reduced. No such simple course is open to the great majority of businesses. Their products, operations and processes are too wide and varied and in such conditions a manager has to face many difficulties in getting broad ideas and in designing, making and developing equipment and bringing it into production. Apart from weaknesses in his own organ-

isation, he will almost certainly have to face problems with outside suppliers of individual items such as conveyors, machines and instruments. Some of these suppliers are most helpful and give full satisfaction. Especially is this so when able companies are interested in a particular project or class of work. But there are too few able suppliers and their combined scope is limited. Weakness in outside help can arise from three main causes: (a) unenlightened policy on the part of a minority of suppliers; (b) inadequate engineering staffs as regards quantity, quality or both; (c) inability of people who might be able to enter the business to see the great scope. When he has difficulties with home suppliers, the manager may be tempted to find out what firms abroad are able to offer. If he can get what he wants abroad and home equipment is inferior or not available, the manager has the task of deciding what is the proper course. Nearly always the manager will be right to base his decision on the grounds of safety for his staff, reliability and technical and economic merit, irrespective of the country of origin.

Special purpose machine tool designers and manufacturers in this country, for example, are extremely competent but there are few of them and they do not cover a wide range. Few automation specialists in any class have the facilities and the urge to go into factories and make a survey of the scope in their particular field. Admittedly some firms, including some machine tool manufacturers, are doing this, but only on a very paltry scale. Why should the manager and his staff be expected to think out and plan projects in a better fashion than those outside firms that are recognised specialists? The great majority of outside concerns are limited as regards technical capacity and have to be content to sit at home and await orders—preferably of the very bread and butter standard type. It is very well worth while to spend time and effort in encouraging outside concerns to develop better and fuller facilities for supplying automation equipment, since any success in the effort will tend to reduce what can often be one of the major difficulties of management in developing automation.

Conclusions

It has been shown that automation is evolutionary and not revolutionary. It is a natural development of mechanisation and is, therefore, certain to progress in almost all branches of industry. The customer, in his demand for the best value for money, will inevitably drive out of business those manufacturers who could apply automation on a significant scale but do not do so. This is not to say that "push button" factories with extreme rigidity of operation will be necessary, or even possible, on a large scale. In the first place a "push button" system is not yet available and cannot be applied until more has been done in developing self-regulation of automatic plant. Secondly, there are many industries where the changing tastes of customers would not allow rigidity of operation. In these industries, progress with automation must be compatible with the necessary adaptability.

It has also been shown that, when correctly applied, automation in industry may improve one or more, or possibly all, of the following five important factors:— working conditions, product quality, productivity, output and costs. If automation is taken to mean, say, merely transfer machines and electronics, then it can do much to improve a very few factories and industries. But if the term automation is construed in the widest possible sense, then automation can do much to improve many factories and industries. If a manager successfully applies automation in his own factory he is helping to raise the level of achievement and esteem of his company, to improve the lot of all those on the payroll and to give his customers better value for their money. If automation can be successful applied throughout a whole industry, then that industry and all the people employed in it will prosper and there will be some rise in their standard of living.

Britain depends mainly upon manfacturing industry for the well-being of her population and for her general prosperity. The more manufacturing industry as a whole prospers, whether through automation or by any other means, the higher will be the general standard of living and well-being of the whole population of this country. Whilst automation could be the most important single factor in raising the standing of a particular business or industry, it cannot be claimed that automation is always the most important single technological factor making for progress. In industry as a whole the order of importance is probably research, design, basic engineering for production and automation. It is all of these factors together that largely determine the success of manufacturing industry, and consequently the prosperity and standing of the British people. Therefore, in taking pains to understand the problems of automation and then encouraging its use on the widest practicable and economic scale, industrial management is doing much to improve the fortunes of Britain.

COUNCIL ELECTIONS, 1955/6

As a result of the Ballot the following Members have been elected to serve for the year 1955/56:—

Members:

G. R. Blakely; A. E. Clifford; H. H. Dawson; A. F. Kelley; E. Levesley; R. N. Marland; H. S. Smith; H. Tomlinson.

Associate Member:

R. Hutcheson.

The next Council Meeting will be held at 10 Chesterfield Street, London, W.1, on Thursday, 21st July, at 11 a.m.

DISCUSSION GROUP 1C

MARGATE CONFERENCE

THE COMPUTER—
ELECTRONICS' CONTRIBUTION TO PRODUCTION

by R. H. BOOTH.

Mr. Booth

After taking a first-class honours degree in Physics Special at Reading University, Mr. Booth joined A. C. Cossar, Limited in 1940, where he was concerned with valve design.

In 1947, he took up the position of Head of the Applications Department of Electronic Tubes, Limited, subsequently becoming Head of the Valve Design Department. In 1949, he joined E.M.I. Engineering Development, Limited, where he is now Technical Manager of the Industrial Applications Division, at Hayes, Middlesex.

AT an I.Prod.E. Conference it is not surprising to find the word "Production" in the title of a Paper, and if the Conference is in 1955, it can be expected that the word "Electronics" will appear somewhere. But why "Computers?" What have they to do with the Automatic Factory, and why should they be hailed as a contribution to production? There are naturally many answers to these questions, but it is proposed in this Paper to concentrate on one theme, control.

Production engineers are vitally concerned with control—control of materials and control of processes, which in turn means control of timing, of temperature, of dimensions, of many other variables which only too often live up to this name. Control mechanisms of one sort or another are old and widely used, and electronics has long played its part in the process.

A good example of the use of electronics in introducing precise control is given by the application of the ignitron to resistance welding. Without its use, or the use of some other electronic switch, short, heavy current welds are very difficult to obtain, because the currents cannot be adequately handled by ordinary relays and contactors. Furthermore, the time is not controlled accurately, whereas with an ignitron circuit the weld can be made to last a predetermined number of cycles and to consist of a defined fraction of each.

This is a very simple form of control, because only one quantity, time, is controlled. Equally simple, and less complicated to carry out, is the use of an ordinary thermostat in maintaining a constant temperature in an oven.

The main function of these controls is to keep some quantity, such as time or temperature, constant. An only slightly more complicated case is where the controller has to make one quantity directly depend on another.

None of this, however, can be called computing. What is a computer? What type of control qualifies to be called computing? For the purposes of this Paper, a computer is defined as a box whose output or outputs depend on the values of two or more inputs. This type of controller can be non-electronic, but is almost always driven to electronic methods because combinations, i.e., multiple functions, are much more easily dealt with in that way.

As an example of the successive degrees of complication of control, consider how a milling machine can be made to operate automatically. It is assumed that it is required to cut a cam such as that shown in Fig. 1.

In the purely manual use of a milling machine, the relative position of workpiece and cutting tool is controlled by hand setting; the blank may be fixed to a turntable and a slide moved so that at successive angles enough material is removed to arrive at the

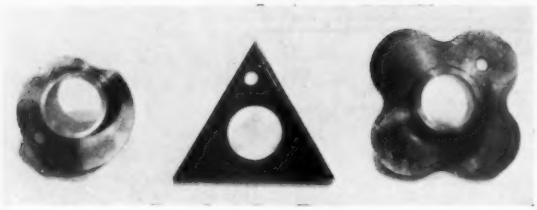


Fig. 1. Cam.

correct radius. This method fits a specification or drawing in which the cam is defined, in polar co-ordinates, by a table of figures and it is left to the operator to blend the successive points into a smooth line.

By successive cuts, with intervals between for inspecting what has been done, a skilled operator will be able to make a cam which will comply with the drawing. Having done so, a machine such as that shown in Fig. 2 can be used to make further samples.

This machine has two turntables, linked by a longitudinal shaft so that they turn together. One table, as before, carries the work being machined, but instead of being manually controlled, its slide position is held so that the distance between the tool and the centre of the table is the same as that between the centre of the other table and a "fixed" copying stylus. To do this requires only a simple proportional servo system, with the pressure on the copying stylus (converted into infinitesimal movement) giving rise to motor drive on the lead screw controlling the slide position. In the diagram (Fig. 3), pressure on the stylus S from the master M is amplified in A_2 and provides the motive power for the motor M_2; this is geared to the lead screw L_1 and if the sense (positive or negative) of the connection is right, the system will operate at any point round the periphery to keep the pressure on the stylus substantially zero and thus keep the other table away from the cutting

Fig. 2. Copy cam milling machine.

head by an amount equal to the radius of the master at that point.

There has intentionally been no mention of how the pressure on the stylus is converted into motive power of the motor; indeed there need be no motor, in the sense of a unit providing rotary motions to a leadscrew. The stylus could operate a hydraulic system in which it released substantially greater oil pressure which directly propelled the table. Or the pressure could be converted in various ways into a

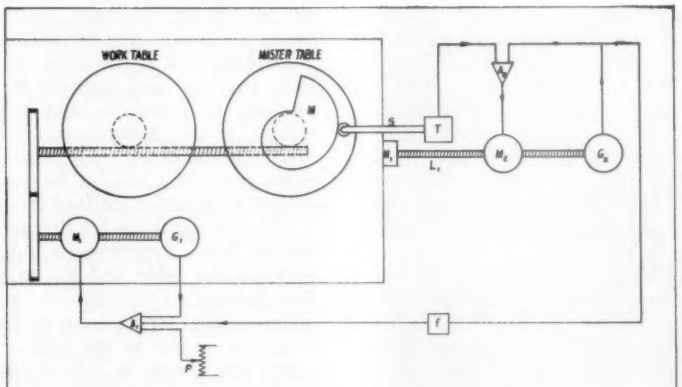


FIG.3. DIAGRAM OF SIMPLE COPYING MACHINE

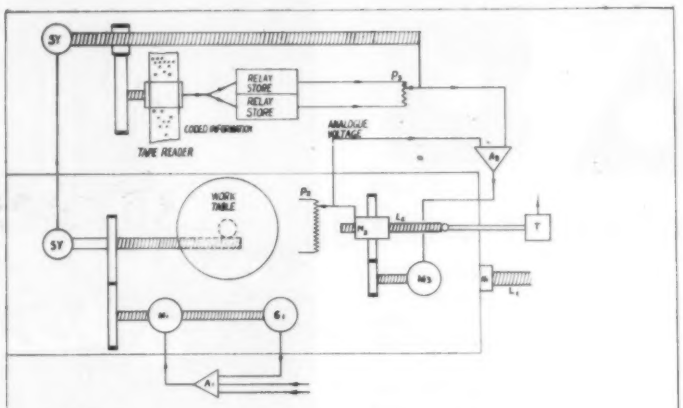


FIG 4 TAPE INPUT AND LINEAR INTERPOLATION REPLACING THE SECOND TURNTABLE OF FIG 3

voltage, which is amplified in an electronic amplifier to drive an electric motor. As long as only the simple proportional control is wanted, it does not matter which is done.

But suppose an extra requirement is added: that when a steep cut is being made, the table speed is to be reduced so as to avoid excessive linear cutting speeds. This is not so straightforward hydraulically, but can easily be carried out electronically.

The diagram had perforce to illustrate a particular type of servo system and has, in fact, shown an electronic method of achieving the extended aim.

A transducer T is used to convert the pressure on the stylus S into electrical voltage and there is a tachogenerator G_2 to provide velocity feed back for stabilising purposes in accordance with the dictates of ordinary servo theory. This same generator is used to control the speed of the table motor M_1. As shown, this motor will run so that the sum of the voltages from the potentiometer P and the longitudinal generator G_2 (as modified by the function box F) balances its own generator voltage from G_1. If F is set so as to attenuate G_2 completely, then M_1's speed will be simply proportional to the potentiometer setting, but as G_2 is allowed to become effective, it will act so that an increase in radial speed will reduce the "demanded speed" from P and so the actual speed of M_1. The latter is now controlled from more than one source and so there is a computer, however elementary, at work.

In spite of this complication, the positional control of the table position has remained a simple one. But if automatic control of this machine is carried a stage further, to the extent that it needs no master to work it but can use information direct from a drawing, then it will be found that the position of the table has to depend on more than one item of information, and there is still more computation.

Information on a drawing is rarely continuous, particularly when it is for a contour of this sort. Usually the information is in the form of a table of figures and as such it must be fed into the machine. Well-known techniques for recording information for machine purposes exist: punched cards, punched tape or magnetic tape can be used. Punched tape is often convenient; the meanings that various hold positions may have is illustrated in Appendix 1.

When the hole pattern has been read by the machine, it cannot be used in isolation to control the table position. If it were, the table could do no more than proceed in a series of jerks from one dimension to the next, and could only produce some semblance of the required shape if the points on the tape referred to angles extraordinarily close together.

If, however, two points are used by the machine at a time, then as soon as it has read the first pair it knows where it must go to next and can act appropriately. It can draw a straight line from one point to the next and proceed along it.

This is a rather anthropomorphic argument but it can be turned into terms more appropriate to engineering. Consider the block diagram in Fig. 4.

Looking first at the slide, the second turntable has been removed and replaced by a new leadscrew L_2 working in a nut N_2 and bearing on the copying stylus. It also reproduces a feed back voltage from a potentiometer P_2. The motor M_3 drives the leadscrew until this voltage balances that from potentiometer P_3 which is derived from the tape.

The arrangements for driving the turntable are unaltered, but a synchronous link, SY, has been added between the table and the tape reader. The latter thus proceeds from line to line on the tape as the table rotates, which is equivalent to running down from line to line in the table of dimensions, and as a new line comes in it is retained or "remembered" until the next line is available and is the means whereby two points on the contour being machined are used together.

Advantage has been taken in the relay stores of other contacts to obtain voltage outputs. This is done by using each relay to switch in a voltage

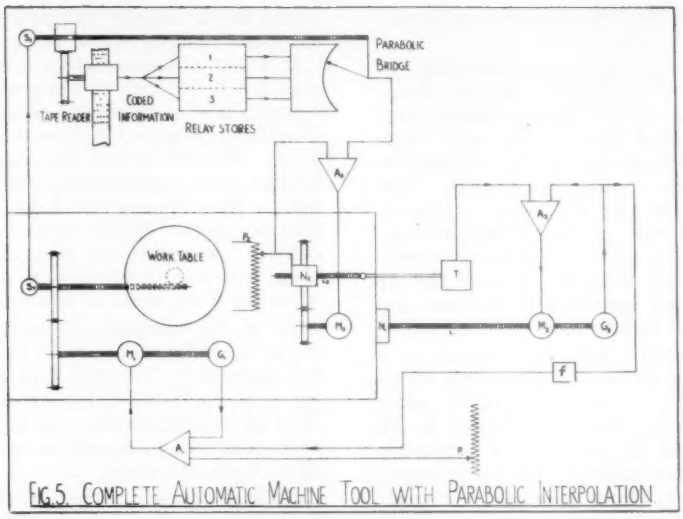


FIG. 5. COMPLETE AUTOMATIC MACHINE TOOL WITH PARABOLIC INTERPOLATION

proportional to the significance of its digital or hole position. The two voltages can now be applied to opposite ends of the potentiometer P_3, whose slider is driven with the tape reader from the synchronous link. A duplicate of P_3 may be used to assist change over from a pair of points to the next pair.

The overall effect of this circuit is to extend the lead screw L_2 by an amount equal to the radius of a polygonal figure composed of lines joining the successive points represented by the dimensions in the table, this radius varying uniformly between adjacent reference points.

With this system there will be no sudden jumps in the position of the leadscrew L_2 and the main servo system will continue to drive the leadscrew L_1 so that the table takes up a longitudinal position relative to the cutting tool corresponding to the polygonal figure above.

Although there are no sudden jumps in the position of L_3 its rate of movement will change suddenly as each new point comes in, and this means that the resultant shape has sharp corners. This can be remedied if we allow the machine to take notice not only of the next point, but of the one after that as well, so that the curvature of successive lines, each now passing through three points, can vary in such a way as to make each "touch" or blend with its neighbour. There will now be, in general, an abrupt change of curvature when two lines join, but this is a far less serious matter than a change of direction.

To make use of three points instead of two requires extra relay stores (Fig. 5) and a new unit called a parabolic bridge, shown only as a block. Its construction is shown in Appendix 2.

Examination of Fig. 5 shows that there are two independent loops. One, comprising A_3, M_3, N_2 and P_2, keeps the leadscrew L_2 at the place dictated by the tape; the other consists of L_2, T, A_2, M_2, L and N. It positions the table on the instructions of L_2 and thus, indirectly, of the tape. The first loop can be eliminated by putting P_2 on L and then using the output of A_3 to drive M_2. The disadvantage of this arrangement is that all dimensional accuracy is referred to a leadscrew (L_1) which bears a considerable load and which is therefore more subject to backlash errors.

Analogue Computing

During the course of the imaginary development just described, a simple manually controlled milling machine has been turned into an automatic machine, capable of milling the cam, Fig. 1, direct from a piece of tape produced by a typist direct from a table of dimensions using a machine such as that shown in Fig. 6. This has only been possible because automatic computing facilities have been introduced, controllers which take account of information from various sources, including internal stores or mem-

Fig. 6. Full keyboard punch for wide tape. This punch will deal with any dimension up to 40 inches to an accuracy of 0.0001 in.

ories, and use it all for guiding the machine's future actions.

This computing has been analogue computing. It is so called because there is always a physical representation, an analogue, of the quantity being computed, in another physical form. The most usual one, and the one employed here, is the representation of length or angle as an electrical voltage. This is common because of the ease with which voltage is converted to and from other physical quantities, e.g., from angle of rotation by means of a potentiometer, and the ease with which different voltages can be combined and modified, particularly if they are alternating voltages and transformers can be used.

With a physical quantity, whether a length or a voltage, there is a limit to the accuracy with which it can be known. This is not important in computing, providing that the analogue quantity, in the present case voltage, can be known more accurately than that which it is representing. Jig borers apart, it is doubtful whether machine tools can be considered more accurate than one part in ten thousand (0.001″ in 10″), and this is the accuracy, with perhaps two to one in hand, which should be aimed at in the electrical computing circuits. Until recently this was not possible, but a new technique has recently been evolved which enables voltages (strictly speaking their ratios) to be manipulated to an accuracy of one part in fifty thousand or better.

Analogue computing is also particularly appropriate when it is necessary to control physical quantities which can vary continuously, such as the table position in the machine tool. When, however, artificial concepts such as money are involved, analogue computing ceases to be so apposite, because with non-natural or non-physical quantities there is rarely a limit of accuracy which can be unambiguously stated, and the quantity rarely changes continuously. In these cases digital computing is appropriate. It is much more similar to conventional calculation, whether done mentally, with pen and paper, or by abacus or bead frame, methods it may be remembered which were primarily developed for financial reckoning.

Digital computing deals in numbers, in states, in "is's" and "isn't's," not in quantities. An electronic computer is not in general concerned with how many volts there are on a wire, but whether there is a voltage there or not. Ultimately, of course, there must be a limit at which one says, "above this is something, below nothing," but successful design ensures that this limit is rarely if ever approached from either direction.

Analogue computing was considered as applied to an individual machine tool, to the direct control of the physical process. Digital computing may now be used to extend this control to the working of the whole factory.

Start of the Process

The process may be assumed to start with the placing of orders on the shop floor. There is no reason why it should not start earlier, but to do so would invoke no new principles and would not help the understanding of the more restricted phase.

It is further assumed that there is a description of each article in terms of the processes that will make it; e.g., how many hours of machining, how many of plating, of assembly, how much raw material and so on. We will assume that there are many different articles being manufactured at once in the factory, and so planning and scheduling are extremely complex problems. It will be seen immediately what a big step forward this is from the machine tool problem, where the computer only had to take account of two or three items of information.

As in the machine tool problem, the first step is to put the information into a form that the computer can assimilate. Punched tape could be used again, but it is probably more convenient to assemble a stack of punched cards, each carrying all the information concerning one article or operation, or to use direct keyboard entry.

A batch of cards, a day's worth or a week's worth, having been put into the machine, the totals of each class of work and each type of material can be arrived at. To go further than this, the computer requires knowledge of other things, the total capacity available, the raw material stock position, and so on. This means the possession of quite large storage facilities. Stores were met with in the machine tool computer, but these served only as temporary stores for retaining one or two dimensions until that part of the contour had been machined. The stores required in planning computers may be described as permanent stores; although the information in them may and will change, the changes are in random sequence and occur at random intervals. If an article requires two dozen 4BA screws, then its passage through the computer will alter the stock position by that amount, but the next article that comes along may use 4BA screws or it may not. If it does, the item that follows the screws will in general be totally different from the first two articles.

Also, the size of the stores is very much larger than previously experienced. Each milling machine relay store was capable of holding one number of four or five decimal digits; if a stock list contains 10,000 items, it may need to hold that number of four digit numbers for identification alone. In addition, another four digit number will probably be required for the stock position, and a third for minimum stock; other information perhaps required to be catalogued under each item includes the value of a single unit and the time taken on average for new deliveries. In computer language this may add up to a store of getting on for a million bits, compared with the fifteen or twenty of the relay stores.

Such stores are conveniently built in the form of magnetic drums. A drum eight inches in diameter and eight inches long can store a million bits and be referred to by the machine in a fraction of a second.

Another store is required for shop capacity under whatever headings, such as turning, milling or assembly, as are appropriate. This may be of varying degrees of thoroughness, ranging from a mere block

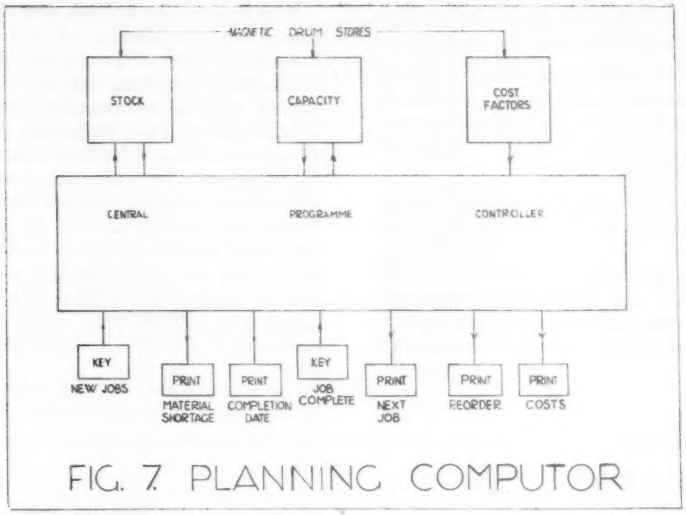


FIG. 7. PLANNING COMPUTOR

allocation of hours to a detailed allocation of each hour of the day to a particular job.

In this latter case it may be supposed that the system is to carry a forward load of a month—say 200 hours—and that there are 250 units, either machines or men, to be considered. Then storage is required for 50,000 unit-hours and it will here be assumed that there is no point in breaking down the time further than one hour. Each article is assumed to take 500 hours on the average and to be broken down into 50 operations. Thus to each of 50,000 forward man hours, a four digit job number is to be allocated. This again means a store of about a million bits, but considerable economies can be made because each operation will normally take more than one hour.

A further input will be required; the store representing available capacity must always start at the right point. The meaning of this will be seen if the system is considered as it might start up after a long shutdown; the first card calling for, say, turning capacity is loaded and will take the first, say, 10 hours of lathe time; others will go on in parallel until one comes along indicating the need for capacity in excess of that immediately available. It must then take its place in a queue, and be timed to begin as soon as the first machine is estimated to be free. But this estimate may be wrong; as soon as a better estimate, or the news that a job has finished, is available, it must be entered into the machine so that any computation of the completion time of future jobs is as up to date as possible. It is important to have this information in the machine at the earliest possible moment, and so a direct keyboard entry should be used.

A number of outputs will be wanted as well. Immediately on entry of the first card, there should be a printed output of any raw material or component shortages. Another output channel should print out the completion time of each article, as computed on the basis of the information inside the machine, and other information which should appear automatically includes re-order requests, when minimum stock is passed on any raw material, and item, unit or article costs both estimated and actual.

We may then envisage the operation of such a computer as follows (Fig. 7):—

1. Shop loader keys in jobs to be done as they are received from estimators.
2. Computer refers to material stock drum and prints out shortages, with average delivery time.
3. If no material shortages (or perhaps no delivery dates longer than a certain time, say two weeks), takes up next free line on each class of work.
4. Based on this allocation (which must of course take into consideration such principles as the manufacture of piece parts before assembly) the computer prints out a schedule showing the anticipated delivery of each item fed in at (1).
5. Completion of any item is fed into the computer by a suitable operator—perhaps the shop clerk or a stores clerk, or inspection personnel. Also keyed is the actual time taken (for costing purposes) if the computer does not already have enough information to deduce it.
6. As each item is complete, the computer issues information to the shop for the next item. This will only be done if there are no material shortages, and it should be possible to issue store vouchers during the course of the preceding job so that material is already earmarked.
7. The information entered under (6) will immediately affect the internal organisation of the machine but will not print out new schedules until a routine regular time (say, once a day) or on request.
8. As raw material stocks are depleted, re-order requests will be printed out, either at a minimum stock level or at an anticipatory time dependent on delivery time and previous rate of usage.

9. Also printed out will be costs, at whatever stage and in whatever detail they may be required.

It will, it is hoped, be appreciated that the above description of a hypothetical machine is intended to be suggestive only. Many stages of design, electronic and clerical, are required to turn a broad conception such as the above into physical reality.

The above illustrations have been concerned, rather narrowly perhaps, with various sides of the mechanical engineering industry. The principles have in fact an unlimited field of application, to any case where automatic control of one sort or another is required. There is, for example, the automatic weighing problem, a demonstration of which is available in another place.

The computing in this case is mainly involved in converting a succession of individual weights into a cumulative one. The equipment basically consists of a weighing machine having an electrical pick-off system, used to preselect the amounts of various substances needed by a particular process. All the substances are heaped on the scalepan in turn before the discharge and the scales are therefore concerned with cumulative weights only. The preselection can be carried out in several ways, including dial setting and the use of punched tape. In either case it is convenient to use the actual weight of each substance and not the accumulating total, since any change in one constituent should not involve, for instance, the resetting of all dials but only the one actually concerned.

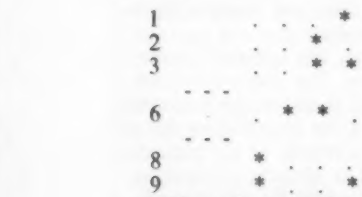
APPENDIX 1

The recording of information on punched tape.

We will assume that a dimension such as 3.546 has to be recorded. This may be the radius in inches of a cam and be one of many given in succession and applying at successive equally spaced angles.

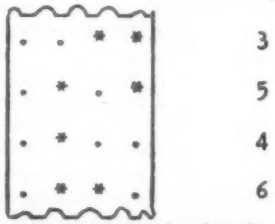
An important requirement is that the punching of holes shall be an unskilled task requiring neither undue mental nor physical effort. This dictates that there shall be a key pressed for 3, one for 5, one for 4 and one for 6. Had a figure been repeated it would have been immaterial whether the same key was used twice or whether adjacent keys, similarly labelled but in different columns, were used.

This requirement leads to the use of the decimal binary code. In these are four possible hole positions and the combination actually used shows how the number is made up out of the numbers 1, 2, 4 and 8. The example below shows how the system works :—



This code is used for each decimal digit in turn. The group of holes may be placed either side by side on a wide tape, so that a long line of holes represents the complete number—3.546 being

or one after the other on narrow tape



The details of the mechanism for reading the tape will clearly differ in the two cases but this makes no difference to the overall conception.

It is important to realise that there is no difficulty in achieving any desired accuracy in the recording of information in this way. In the narrow tape method, it will be readily seen that there is no more problem in adding further rows of holes than there is in adding further decimal digits to an ordinary row of figures. Nor, may it be added, is there appreciably greater requirement on the accuracy of placing holes than on the accuracy of placing figures ; the machine must be able to distinguish between one position and the next but no more.

APPENDIX 2

The Parabolic Bridge—Fig. 8.

In (b) the curved line represents a plot of radius against angle. The points A, C and B are equally spaced in angle.

Voltages are available from the stores proportional to the three radii and it is required to produce intermediate voltages lying on a parabola drawn through ACB.

The line AB may be drawn first and is equivalent to the potentiometer P_3 in Fig. 4. M is its mid point and N is any point on AMB.

An auto transformer AB in (a) can be supplied with the voltages corresponding to A and B and a

series of tappings on it will give voltages corresponding to M and N. The primary of another transformer may now be connected between M and C and will bear the voltage corresponding to MC. Secondary windings may be wound on this transformer, whose turns vary according to a quadratic law in the figure MC having say 5^2 turns and successive secondaries 5^2-1^2, 5^2-2^2, 5^2-3^2, 5^2-4^2, and $5^2-5^2=0$ turns

One end of each of these secondaries is connected to the appropriate tap on transformer AB and the far ends then bear voltages on ACB, P for example being produced from N.

The gaps between the voltages corresponding to points such as P can be filled in linearly, e.g., by the potentiometer shown.

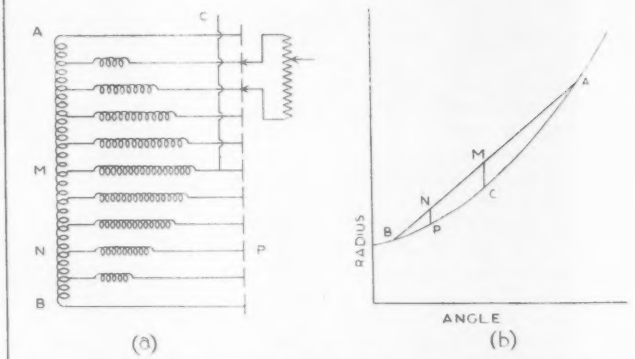


FIG. 8 - PARABOLIC BRIDGE

MARGATE CONFERENCE
DISCUSSION GROUP 3A

ATOMS, ELECTRONS AND AUTOMATION

by A. G. Peacock, B.Sc., A.R.I.C., M.Inst.P.

Mr. Peacock

Mr. Peacock is a graduate of the University of Bristol and has had a wide experience in instrument problems in many fields. With an academic training in chemistry and physics, he has spent most of his career in the engineering industry. He is, perhaps, best known as Honorary Exhibition Secretary of the Physical Society and also for his connections with the Scientific Instrument Manufacturers' Association.

Mr. Peacock is Director of Mervyn Instruments, Woking.

WHEREVER and whenever that child of modern production technology, "The Automatic Factory" is born, electronics will be there. For, just as in the First Industrial Revolution man's strength was replaced by the power of the machine, so, in this Second Industrial Revolution, his judgment will be replaced by electronic controls. If the Automatic Factory is to have any meaning at all, then more and more intelligence must be built into automatic machines, and the easiest, the most flexible and the most reliable way of doing this, is to use electronic techniques.

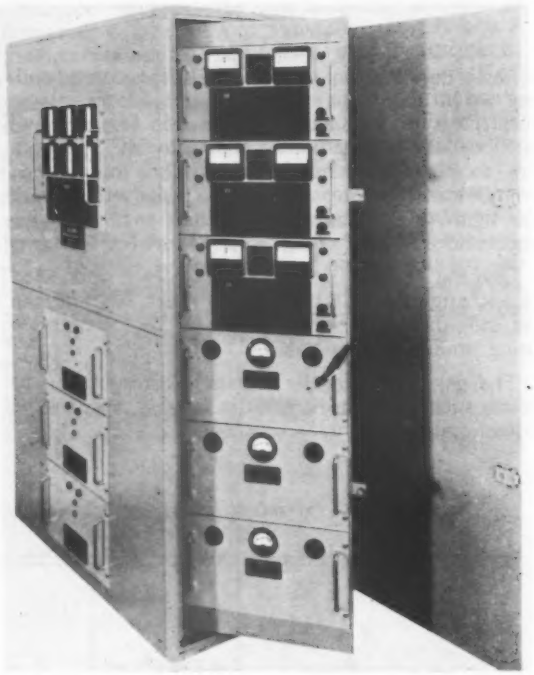
The purpose of this Paper is to try to demonstrate the importance of electronics in the Automatic Factory and, by stimulating a fuller understanding of all the problems involved, to hasten the acceptance of what was once the *enfant terrible* of precision engineering. Perhaps, at the outset, we should attempt to make some broad definition of the word electronics in its present context. To many engineers, electronics is still only a simple extension of the domestic radio or television set which he has in his own home. This may have been true to a limited extent, perhaps fifteen or twenty years ago, but

today, electronic engineering is a science in its own right and electronic devices are engineered to the highest possible standards for precision, efficiency and reliability. In a narrow sense, an electronic device is one which uses the properties of free electrons moving in a vacuum. That is to say, it uses an electronic valve. However, for the purpose of this talk, I think it would be better to adopt a rather broader definition, that is to say, any device which employs valves or closely related equipment such as transistors, in a circuit using combinations of capacitors, resistors and inductances which generally follows the conventions of electronic engineering. As far as the design of equipment for the Automatic Factory is concerned, the electronic valve has several fundamental properties which are of importance. First of all, under controlled conditions, it can be made to operate as a switch, hence the term " valve." But it differs from most other types of switching systems in that its operations can be controlled with very great precision. But it can do more than this. In a different circuit it can be made to amplify in voltage and power small signals which are impressed upon its input and repeat them faithfully at its output. Electronic circuits can also be arranged so that they convert variables from one function to another. Thus, a function presented to a suitable circuit can be expressed logarithmically or as a differential at the output. These properties enable the electronic engineer to devise equipment which has three vital properties of great significance in the Automatic Factory. Firstly, these devices can have extreme sensitivity. Secondly, they are extremely flexible and of wide application and thirdly, they can very easily be arranged to incorporate feed-back systems which are essential to all forms of automation.

Fundamental Properties

Sensitivity

Let us examine these three properties in turn and see how they affect the Automatic Factory. Instruments first left the laboratory when Lord Kelvin developed measuring equipment to determine the properties of the first Transatlantic cable. Since he knew that the signals to be detected were extremely small, the devices he used had inevitably to be extremely sensitive. The only way to obtain this sensitivity was by making the most delicate and fragile equipment. In those days, of course, systems of electrical amplification were almost unknown and Lord Kelvin did not have at his disposal any form of electronic instrumentation. When a device is to be installed on a machine which is to be incorporated in an Automatic Factory, it almost inevitably has to work under extremely arduous conditions. It may get extremely hot ; it may be subjected to extreme vibration ; it may be periodically sprayed with oil ; it may itself even have to withstand large external forces. Under these conditions, delicacy and sensitivity are just not possible. With the advent, however, of the electronic amplifier, new schemes were possible. Sensing devices could be made much more robust. They could withstand the most arduous conditions even though their output was extremely small. This was of no significance for, with the aid of electronic



Nucleonic Thickness Measurement. **Part of the control system of an installation showing built-in test equipment for ease of servicing and maintenance. (Baldwin Instrument Co. Ltd.)**

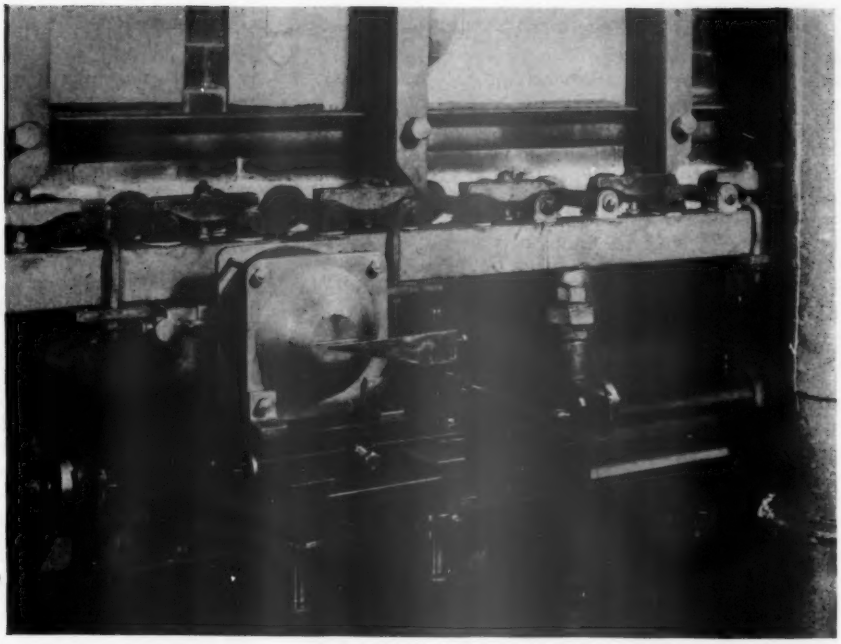
amplifiers, their output could be magnified many thousands of times and used for indicating, recording or controlling.

Flexibility

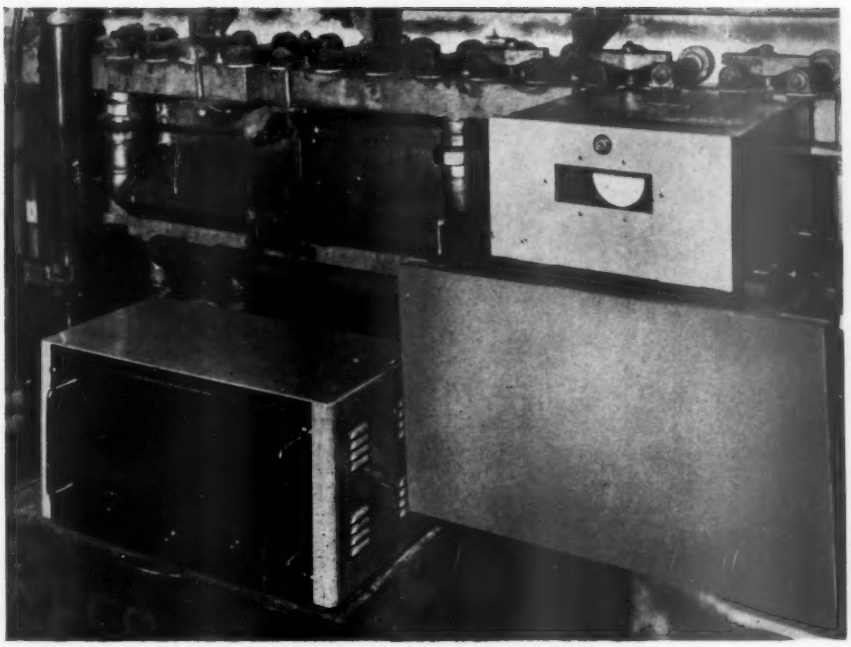
The second factor in favour of electronic controls is their extreme flexibility. Before electronics came into the field there were, of course, many control systems which worked satisfactorily. First of all, there were mechanical systems, of which the centrifugal governor, invented by James Watt in the latter part of the eighteenth century, is a well-known and early example. Hydraulic and pneumatic systems are also possible and have many advantages of simplicity and robustness. They have, however, an inherent disability in that it is not always easy to change the parameters which have to be controlled into mechanical, hydraulic or pneumatic forces directly. The electronic instrument which handles electrical signals is particularly fortunate in this respect, for almost any physical quantity today can be converted into an electrical output. Thus, light can be made electrical through the photo-cell and transducers exist for converting temperature, flow, pressure, displacement and many other quantities into electrical signals.

Incorporation of Feed-back Systems

Now, while these two properties already mentioned are of vital importance in making machinery automatic, they do not in themselves render possible full



Liquid Glass Level Gauge **(A). The source unit of a nucleonic level detector mounted on one side of the forehearth or feeder channel of a glass furnace. The channel section is about 30″ wide by 9″ deep, with a wall of hard refractory about 5″ thick surrounded by brickwork and a steel casing. The molten glass level is normally 1″ below the top of the trough and has to be maintained within ± 0.080″;**



Liquid Glass Level Gauge **(B). The detector unit is mounted on the opposite side of the feeder channel to the source unit. The unit is water-cooled since the ambient temperature is about 150°F. (Isotope Developments, Ltd.)**

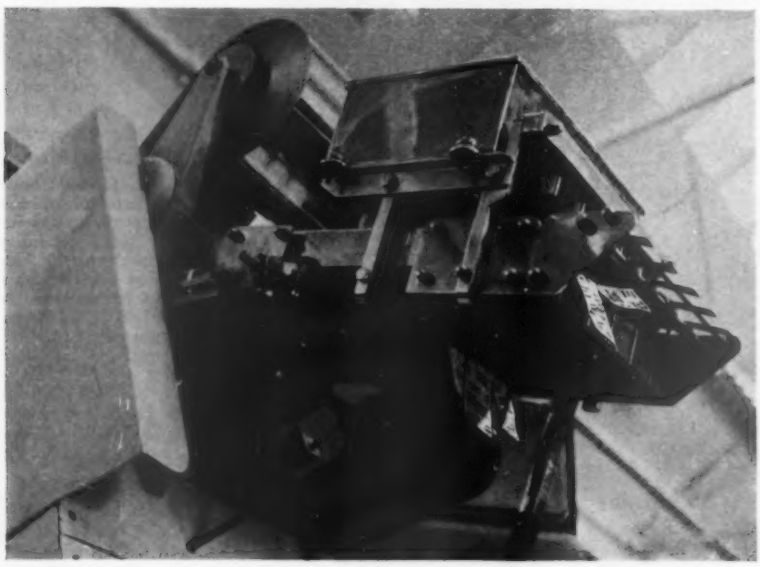
automation. It is this third property of electronic systems, the ease with which it can incorporate feed-back, that does this. The theory and application of feed-back systems, servomechanisms, and the like, are extremely complex and involve consideration of many factors and must be simplified for discussion here. A feed-back system, therefore, can be said to be one which continuously measures its divergence from some pre-determined condition and tries at all times to reduce this divergence or error to zero. The importance of such a system to the concept of the Automatic Factory is at once obvious, since it envisages the possibility of continuously controlling a manufacturing process to ensure the maintenance of the pre-set standards of the output or product. Many devices exist today which, often using electronic techniques, can indicate the instantaneous value of some variable in a manufacturing process. However, the most common control technique is to engage an operator to observe the reading of the indicator and to adjust his controls to maintain its value constant. The operator is an essential link in the process and himself receives the signal and uses his powers of judgment to adjust his controls suitably. The control loop of the process is thus closed by means of the operator. In a fully automatic process, however, the loop will be closed by a suitable electronic feed-back system, with many attendant advantages. For example, it can detect the minutest changes in the system and may easily anticipate conditions by measuring the rate of change of the signal. Its action can also be extremely swift. In passing, it might be mentioned that the automatic pilot operates on a system very similar to that described above, and is commonly all-electronic in operation. In the chemical and petroleum refining industries, this has also been done in controlling such variables as temperature pressure and flow ; often, and increasingly, using electronic systems. Other and more complicated problems remain to be solved if the Automatic Factory is ever to exist. In some cases, the control systems will lend themselves to mathematical analysis, while the final solution will often be reached—particularly in the immediate future—by more empirical methods. As the problems become more complex and more variables are introduced and closer control demanded, the flexibility of electronic devices will bring them increasingly to the fore.

Three Important Factors

The importance of electronics can, therefore, be summed up under three headings. Firstly, the essence of a control system is a measuring device. This must be both sensitive and robust. Electronics can use a sensing element which is extremely sturdy and, if its output is small, it can be amplified to any desired level. Secondly, measuring elements must be available to detect the widest possible range of parameters; pressure, temperature, flow, level, position, speed, displacement and many others. Electrical transducers are available in every case. Thirdly, fully automatic control hypothesises the use of feed-back systems or servomechanisms and these can most readily be realised through electronics.

Applications in Process Industries

As has already been stated, many applications of the foregoing principles have been adopted particularly in the process industries. New uses are being described continually, and no doubt more will be revealed during the discussion on this Paper. Their speed of adoption, like so many technological developments, is decided by economics or dire necessity. For example, in printing cine films, different densities of the negative call for different printing times if uniform density is required in the final print. The same effect, however, can be obtained by varying the intensity of the printing light source. The speed at which the film passes through the printer and other factors precludes the possibility of human control,



Package Monitor. **Underside view of the delivery end of a package monitor using radio isotopes, showing two accepted packets and three rejects. (Isotope Developments, Ltd.)**

but a suitable automatic device has been in use for many years. The sensing element measures the average density of each group of negatives, compares it with a standard density, as a result of which a signal is derived which adjusts the intensity of the printing light. When the particular negatives are passing over the printing head, they, therefore, receive the appropriate exposure.

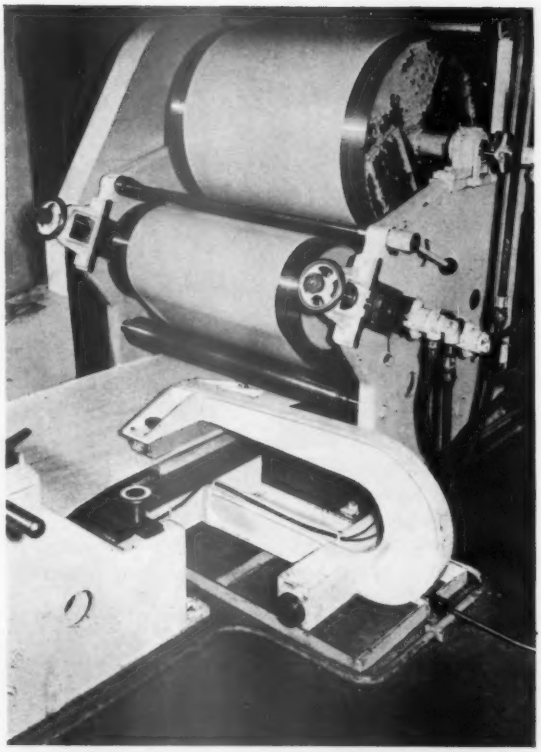
Another device is in use with a completely different type of printing. This is when patterns in several colours are reproduced on rolls of paper, cloth, plastic or other materials. The problem is to obtain register when the paper runs through the machine at high speed. This necessitates guiding the paper without using the edges as datum. When the first printing is being done, a line is drawn near the edge of the material. During subsequent printings, a suitable pick-up using a photo-electric principle can follow the position of this line and through a servo system guide the material evenly through the printing rollers.

Although there are many uses for electronics in primary manufacture in the Automatic Factory, it may well be that its most important role will be in automatic inspection. A familiar example lies in the detection of metallic particles, particularly in foodstuffs. Such a device employs a sensitive head which is affected by the passage of metal particles beneath it. When the head is energised by the presence of metal, the electrical signal produced can be amplified and then used to ring an alarm, mark a defective packet, reject it from the production line, or carry out some similar operation.

Electronic devices can also be made to count at very high speed and this is of great use in automatic processes. Single components, packets, bottles and all sorts of containers can be accurately counted at speeds far too great to be dealt with by mechanical counters. Other novel inspection systems are dealt with later in the Paper.

The Other Side of the Picture

But, so far, we have only considered one side of the question, namely, the advantages and uses of electronic techniques in the Automatic Factory. What, if anything, lies on the other side of the picture? Before the War, electronic techniques did not always have an enviable reputation in their industrial applications. This arose perhaps for two reasons. First of all, designs and components were dominated by contemporary radio practice and industrial engineers consequently tended to suspect that the equipment was not sufficiently robust for plant use. In addition, it appeared that users expected that the price should be related to that of domestic equipment produced in large quantities. Thus, while an engineer appeared to be willing to pay almost any price for plant equipment or for elaborate machine tools, it was thought generally that electronic equipment could be manufactured at uneconomically low prices with consequent deterioration of quality. These factors did, indeed, lead to the development and manufacture of much equipment which was not satisfactory for arduous use in the factory, and certainly would not be suitable for use in automation.

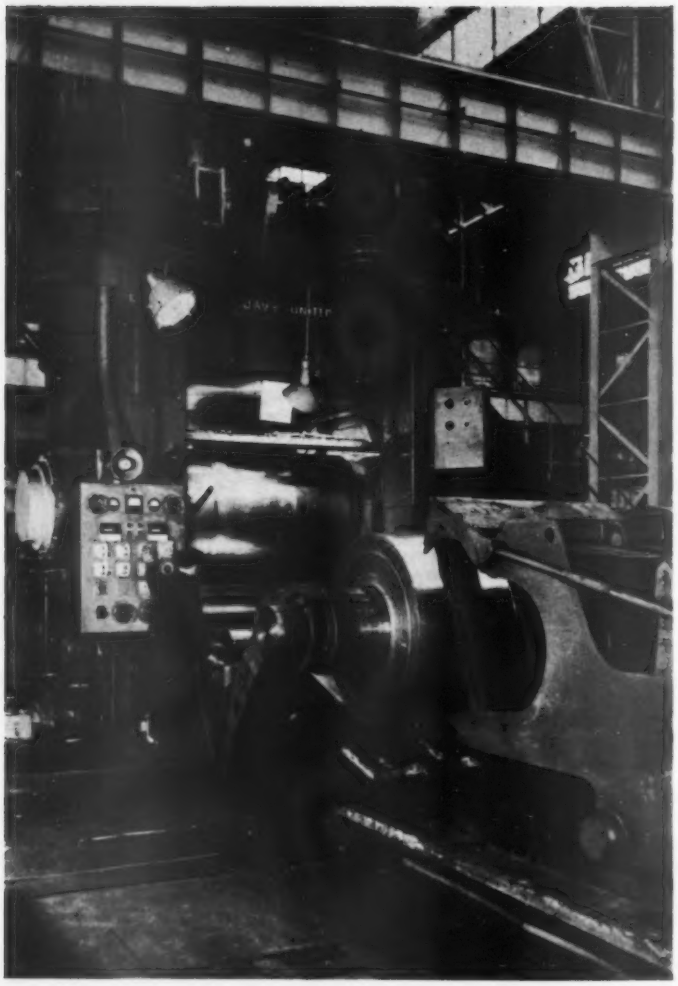


Nuclear Thickness Gauge. **Part of a nuclear thickness gauge showing the source containing measuring head. (Baldwin Instrument Co. Ltd.)**

The situation today, however, is very different and is improving continuously as new advances are made in the field of component manufacture. Let me give you a few examples that will indicate the reliability of electronic equipment today. The first lies in its use by the Post Office in underwater telephone equipment. Here, in, for example, a transoceanic cable, amplifiers are required at frequent intervals along the cable to restore the strength of the signal which is attenuated in its passage through miles of cable. Obviously, once these amplifiers are lowered to the bottom of the seabed, it is a major operation to recover them and repair them and, indeed, since the cables are in use twenty-four hours a day, repair and servicing is almost unthinkable ; but amplifiers *are* made and *do* work under these incredibly arduous conditions. Special valves, for example, have been developed for this purpose and these valves are available for the electronic engineer to build into his equipment for the Automatic Factory.

Application to Aircraft Operation

Nearer home, I would also remind you of the many, many thousands of aircraft flights and landings which have been controlled almost exclusively by autopilots and other electronic devices. If the Post Office and the airliner operators can use these devices and can be convinced of their reliability, availability



An Electronic Extensometer. **Electronic instrumentation working under arduous conditions in heavy industry. The control panel can be seen on the left. (Baldwin Instrument Co. Ltd.—"** ***Machinery*** **"** ***photograph*** **).**

and dependability, then surely they will find similar wide use in industry.

One factor, however, must always be borne in mind ; namely, that reliability is expensive. If equipment is to be made to the highest possible standards, its cost will be in line with other capital equipment and indeed it must be regarded as such.

Serviceability, too, demands the attention of the electronic designer on an increasing scale. Interchangeable " brick " units that can be plugged into equipment are finding a wider acceptance and are of great use in ensuring maximum plant availability. In the case of a fault developing, the defective unit can instantly be replaced and serviced at leisure. The expanding use of electronic equipment in industry has already shown the need for a new type of maintenance engineer and the demand for this class of skilled labour may well bring about a major redeployment of labour in the factory of the future.

Having thus outlined with almost indecent brevity some of the possibilities of the use of electrons in the Automatic Factory, we now turn to dealing with some of those properties of atoms which lend themselves to use in automatic industrial processes. Without plunging too deeply into the most modern conception of the structure of the atom, it is desirable to have some idea of principles which lead to the existence of the so-called " radio-isotopes " and their consequent use as tracers in industrial processes.

When early chemists realised that many substances were so simple they could not be broken down into materials of even simpler structure, these were termed " elements." They included most of the common metals, such as copper, iron, zinc, tin ; many well-known gases such as oxygen, hydrogen and nitrogen and, in all, nearly a hundred materials came in this category. These were investigated extensively over the centuries by successive generations of chemists

and one of the properties which was felt to be of greatest significance was that of atomic weight of the material in question. When some of these were measured, it was found that they were very nearly whole numbers and for a long time it was thought that greater refinements of the techniques of measurement would indeed lead to this whole number idea proving to be true. Unfortunately, several elements stubbornly refused to fit into this pattern. Perhaps the most noticeable was chlorine, whose atomic weight of 35·5 fell half-way between two whole numbers. A suggestion was made by a chemist called Proust that all the atoms in the elements were not exactly the same and that in the case of chlorine, the figure was the average two or more atoms of different weight, their proportion always being constant in natural chlorine. For a number of reasons this theory was not popular, principally owing to the work of the great Manchester chemist, Dalton, who denied that this was possible. Within the last fifty years, however, it has been shown that this idea is indeed based on fact, and that most elements are mixtures of atoms with similar chemical properties, but different atomic weights. These atoms are called " isotopes " and, in some cases, their structure is such that they are extremely unstable and the atoms disintegrate into other products in time. During this disintegration, certain radiations are emitted and the process is known as radio-active disintegration. This process was discovered in France before the turn of the century, and in connection with the element radium, and for many years, radium was the principal material showing the phenomenon. In due course, other naturally occurring materials were discovered which showed this property of emitting radiation, but apart from their medical use, they found little application and this would have been likely to remain so, had not means been found of making unstable isotopes of other elements which, therefore, became radio-active.

There are a number of ways of doing this. One is to irradiate materials in the atomic reactor ; the other is to subject it to bombardment by primary particles in a machine such as a cyclotron, or similar electro-magnetic accelerating device. The net result is that today many metals and compounds can be made radioactive. When a substance is radioactive it emits radiation of three types, and these can be suitably detected and measured by a number of devices of which the Geiger counter tube is the most well-known. Thus the position and amount of a radio-isotope present in a material can be ascertained. It is this property which can bring atoms in the form of radioactive isotopes into the Automatic Factory.

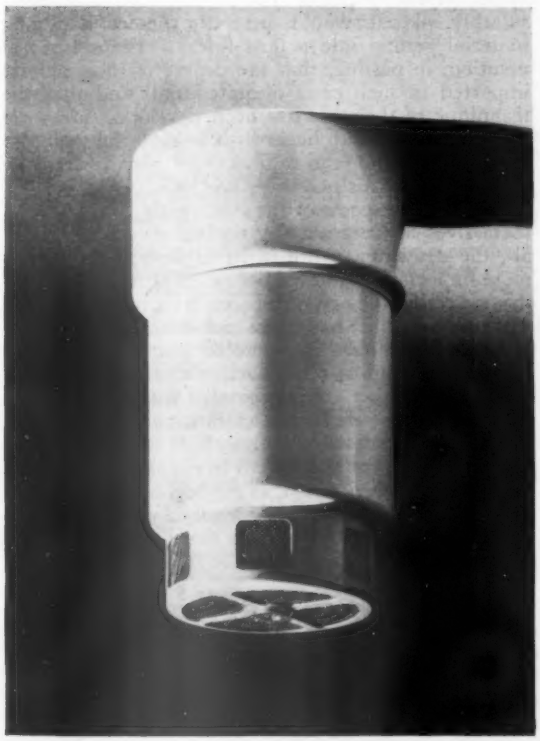
Supervision and Inspection

We have already referred in our discussion on supervision and inspection to the use of electronics, and it is in this field that atoms will make their biggest contribution. A few examples will, perhaps, make the point clear. For instance, in the case of drilling a hole with a fine drill where, perhaps, there is some excessive danger of breakage, if a small amount of radioactive material were introduced into the steel of the drill in its manufacture, then a detector suitably placed on the production line could monitor each component for the possibility of having embedded in it part of a broken drill. This could ring an alarm and stop the equipment until the offending drill was replaced. In addition, of course, the casting in which the broken drill or tap was embedded, could instantly be located. It is appreciated that in an instance like this, there are many other ways of solving this problem, but there is little doubt that there must be applications in which such a solution is the only one.

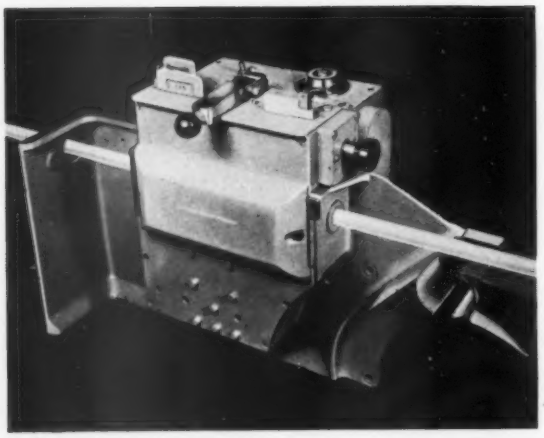
Another problem which must face users of the Automatic Factory is the question of wear, both of tools and of bearings and other vital parts of the machinery. In one case it is possible to monitor the flow of coolant, perhaps, and determine when excessive wear is taking place on a cutter which has previously been made radioactive. Similarly, in the case of bearings, a small amount of, perhaps, radio-active tin, can be introduced into a bush and this can be continuously monitored with a suitable detector at some point in the lubricating system and excessive quantities of tin arising from wear, can easily be measured in the oil.

Identification of Materials

Another possibility which may have significance in the Automatic Factory is the use of radioactive tracers



The Nuclear Fire Detector. **The slightest trace of smoke is detected by a radio-active source which is made to trigger the alarm bell. The detector is mounted on the ceiling and will protect a superficial area covering 2,000 square feet. (The Minerva Detector Co. Ltd.)**



Nucleonic Weight Controller. **The cigarette rod is shown passing through the radio-isotope scanning head which measures any changes of density. (Electronic Instruments, Ltd.)**

to "tag" raw materials which may be passing through the shop and which may be in such a form as to make identification difficult or, it may be, made of different materials of identical appearance. These, again, could be made radioactive and a counter suitably placed would instantly detect a wrong material getting into a flow line. Perhaps I might mention, in passing, that the degree of radioactivity imparted in such cases is quite small and that the technique of their use has been developed so as not to represent a health hazard. The material may also be chosen so that the radioactivity persists for only that time which is necessary and safe.

Two other aspects of the Automatic Factory lend themselves to treatment by these methods. First of all, the detection of fire in its earliest stages will be more important than ever before. For many reasons, the detecting device must reach a new peak of sensitivity. This has been achieved using radio-isotope techniques. The detector consists of a small chamber containing a radioactive source. When the air in the chamber is contaminated with the products of combustion, the current flowing through the chamber is decreased and this effect is used through an appropriate control system to operate alarms and other warning devices. This method of fire detection is so sensitive that it is not necessary for visible smoke particles to be seen to operate the alarm. Invisible products of combustion are quite sufficient to operate the device.

All the three types of radiation given off by radioactive materials are absorbed by matter to a greater or less degree. The absorption is proportional to the density of the material concerned, and apparatus can be devised to measure the absorption of the rays and hence indicate the density of the material. An interesting application of this principle is found in the cigarette manufacturing industry. Cigarettes are made in a continuous tube and are cut off for length at the end of the process. The density of tobacco in this tube is of great importance, both to the smoker and the manufacturer, and it is essential that this is maintained as constant as possible. The density of the tobacco can easily be determined as previously described, and the signal produced from the detecting head can be used to adjust the tobacco feed to ensure the constancy of density of the product.

Determining Thickness of Materials

Since, by definition, density is the mass per unit volume of material, and further, volume equals area times thickness, it is possible that if mass and area are kept constant, the thickness of a material can be determined using absorption of radiation in the same way. This technique has found wide acceptance in industry using materials as diverse as paper and steel sheet. Different types of radiation are, of course, used in each case.

A similar application dependent on absorption exists in the packaging of many powdered materials, such as detergents. In this case, it is necessary to determine the level of powder in the packet. A suitably placed source of radiation and counter can be arranged so that when the radiation increases above a certain level, that is, when there is insufficient powder in the packet, an alarm can be rung, or the packet rejected automatically. It will readily be seen that the existence of such equipment will enable automatic inspection easily to match the speed of automatic production. The field of the use of radio-active isotopes in such devices is increasing daily, and it will be possible to make a catalogue of many hundreds of devices which are fully automatic in their operation and are undertaking jobs of widely diverse character automatically and reliably, every day.

Inspection, of course, is not only carried out on the production floor, but also in the laboratory where raw materials and the like are checked. It is safe to assume that associated with every Automatic Factory will be the automatic laboratory and, here again, electronics will have a substantial part to play. Already many automatic instruments exist which are replacing the monotonous job of routine chemical analysis. The Automatic Factory will demand an ever-closer control on raw materials if it is to work at its highest peak of efficiency and this, in turn, throws additional work on the already over-loaded conventional laboratory. Automatic analysis will provide the only solution and the recent developments in such fields as spectrometry and polarography are already showing the trend in future techniques.

Conclusions

What then are the conclusions that can be drawn from this brief survey of some of the potentialities of electronic and atomic techniques in the Automatic Factory? They are, that the electronic instrument industry in the past three decades has developed many devices which are automatic in operation and which have been serving reliably in many fields. In telecommunications, the reliability of even inter-continental systems is well-known. Aircraft reach their destination safely using electronic devices, and now guided missiles are reaching new peaks of efficiency and are themselves completely automatic

in their operation. All the knowledge that has been devoted to the perfection of these techniques is available to those who build the Automatic Factory. It is, therefore, up to the production engineer to come forward with his problems, to meet the electronic engineer and discuss fully with him in a spirit of co-operation how these new tools of modern science can help. But, at the same time, on his side, the electronic engineer must not be completely carried away by the wonder of his own techniques. The great field for electronics lies in their application to complicated problems which cannot be solved easily by other means. Solutions that demand simple mechanical devices for their elucidation should not be converted to electronic operation purely for its own sake.

Acknowledgments

In the past, the contacts between electronic engineering and production engineering have been scanty. On his side, the electronic engineer has produced perhaps some device which, when associated with some machine tool, has, if not solved the problem, pointed to the future trend in production engineering. This is not, however, enough. The new devices of the Automatic Factory must be conceived as integrated units designed for use in the factory ; designed for reliability ; for easy servicing and for a hundred per cent. availability. This can only be achieved by the closest co-operation. But if, on his part, the production engineer has any reserves in coming forward, let him look to the examples I have already given where electronic controls are solving problems and holding their own with distinction, and regard electronic equipment with the confidence that it demands.

The Author acknowledges his indebtedness to his many friends in the scientific instrument industry who have provided information for this Paper. He is particularly grateful to Mr. K. G. Dobson, Chief Engineer, Mervyn Instruments, Woking, Surrey, for many helpful suggestions and discussions.

CONFERENCE OF STANDARDS ENGINEERS

Wednesday, 4th May, 1955.

OVER 125 engineers responsible for standards matters in industry were present at a Conference held under the joint auspices of the Institution of Production Engineers and the British Standards Institution on 4th May, 1955. The Chairman on this occasion was Mr. R. E. Mills, of the Bristol Aeroplane Company, and Chairman of the Standards Committee of the Institution of Production Engineers.

Mr. H. A. R. Binney, Director of the B.S.I., welcomed the delegates and said that this was the first conference of standards engineers to be held in this country. Such conferences were frequently held in the U.S.A., where considerable benefit was derived from the interchange of views. B.S.I. had welcomed the opportunity of collaborating with the Institution of Production Engineers in arranging this conference and all concerned had been gratified by the enthusiasm which it had evoked. He said that the principal aim of the B.S.I. had hitherto been to produce standards for which there was known to be a demand; they were now concerned with the application of the standards and he wished to assure those present that the B.S.I. would take energetic action on any recommendations put forward by the Conference.

The Chairman then stressed the fact that it was intended to be a working meeting at which it was hoped that everyone would speak. The agenda was completely flexible and could easily be changed if desirable.

Mr. G. Weston, (*Technical Director of the British Standards Institution*) stressed the desire of B.S.I. to be of service to industry and said that while no limit need be set to the discussion, there were specific points on which guidance would be welcome. These included notice of those fields in which it was felt that more national unification of practice was required; suggestions for new projects which could usefully be undertaken; comments on the adequacy or otherwise of the information at present contained in British Standards and on the manner of expressing it and method of presentation. He asked particularly whether there was a more useful form in which certain standards might be published. The standards in their present form were frequently used as instruments of purchase and could provide the basis for contracts, but it was recognised that they were increasingly used in many departments of large industrial organisations and it might be that the normal type of standard could be supplemented by data sheets giving information extracted from the standards. There was also the question of part numbering: the Textile Divisional Council had recently referred to the difficulties of designating parts and requests from other sources had indicated that some form of standard coding system might be helpful to industry.

DISCUSSION ON GENERAL PROBLEMS OF STANDARD ENGINEERS IN INDUSTRY

The discussion was opened by a speaker who said that one of the chief difficulties of the standards engineer was to persuade his organisation to recognise the advantages to be gained by adopting standards. Few people were interested in the theory of standardisation, but wanted proof that its adoption would result in savings on production costs. He thought that such savings would always result, even though it might not always be possible to demonstrate in advance how they would be achieved.

Another important task of the standards engineer was the collection and assessment of technical data. British Standards in their present form were wide in scope, representing the broad views of users and manufacturers—sometimes, it might be felt, with undue emphasis on the latter—and it was often difficult to know how to select what was required. Where expert advice was available the problem was obviously greatly simplified, but where it was not, the standards engineer was faced with a laborious task. It was also a fact that no British Standards existed for many of those matters with which the standards engineer was concerned and for these he must find his own solutions. Furthermore, it was often possible for British Standards to be

formulated for the future, whereas the standards engineer had to take more account of existing practice and had often to adapt a published standard to domestic conditions. The speaker also thought that it would be helpful to establish a means of ensuring, without recourse to elaborate inspection methods, that products supplied were in accordance with the standards. In this connection it might be possible to extend the use of the B.S.I. kite mark. Finally, he felt that a standards engineer should be able to cut across all sections of his organisation to institute a standards policy.

" Selling " Standards

Several speakers agreed that one of the main problems of the standards engineer was to " sell " standards in the works. It was pointed out, however, that support for their views on the economic advantages of standardisation could readily be found in the Report of the Lemon Committee. As a result of their investigations, the Board of Trade issued a recommendation in 1949 that industry should adopt a policy of simplification and standardisation and that senior company officials should be appointed to carry it out. The status and authority of the standards engineer should therefore never be in question in his own organisation, nor should he have difficulty in securing the adoption of standards.

The Conference agreed that the standards engineer should be free of departmental ties and sectional interests so that he could view each project objectively; he should also be brought in at every stage, from design office to packaging department, so that his knowledge of standards could be applied to fullest effect. Speakers who were able to point to the satisfactory organisation of standards departments in their own companies emphasised the importance of their independence.

Among other general matters raised was the desirability of holding more frequent conferences—a proposal which met with unanimous support. It was also asked whether another platform might not be provided, possibly in the form of a magazine devoted to standards matters, as already published in a number of countries abroad.

Reference was made to the difficulties of organisations engaged in the export trade. It was known that the United Kingdom took an active part in international standardisation work and the hope was expressed that B.S.I., and indeed all national standards bodies, would implement ISO recommendations as they were published by incorporating them in their own standards.

It was explained that the object of ISO standardisation was to co-relate national standards and it was thought that questions of policy with regard to the adoption of international standards should be referred to the General Council of the ISO. It was hoped than an opportunity might be found to raise this matter at a forthcoming plenary meeting.

Need for Quality Standards

The need for quality standards was mentioned and it was suggested that wherever possible the standards should afford a guarantee of minimum quality at least, as well as providing purely dimensional information. More guidance in regard to preferred sizes would also be appreciated, it was said, although the difficulties of establishing a basis for their selection were recognised. In this connection, one speaker pointed out that committees themselves were often not simplification-minded. The Conference agreed that there was need for co-ordination both between B.S.I. committees and between outside organisations and the B.S.I. Where many companies were carrying out their own rationalisation schemes there was a danger that too many independent standards might be produced; this could be obviated if B.S.I. were asked to consider appropriate projects on a national basis.

Referring to the content of the standards, a B.S.I. spokesman said that it was inevitable that they should be fairly general in character, since the standards were not intended to cater for restricted sections of industry. Users could, however, help to ensure that proper weight was given to their needs by taking a more active part in the preparation of the standards. It was, regrettably, a fact that, although B.S.I. took care to set up its committees with fair representation from both sides, on most committees it was usually the manufacturers who came with constructive proposals and co-ordinated views. While the reason for this was obvious, it was not impossible for users also to organise themselves more effectively through bodies such as the Institution of Production Engineers, to which many of them belonged. They could also make better use of the opportunity which everyone had to comment on draft standards.

Presentation of Standards

A factor which emerged clearly from the pattern of the discussion was the feeling that there was room for considerable improvement in the presentation of British Standards. One speaker thought that B.S.I. was suffering from complacency—probably inevitable in a pioneer standards body—and that the time had come for an awakening. The publication of standards in loose leaf form would ease filing problems and greatly facilitate reference; it would be particularly helpful if an intelligent classification scheme could be applied in place of the present system of numbering. Loose-leaf sheets would also eliminate the issue of amendment slips, since it would be a relatively simple matter to publish a new sheet.

The standards in their present form were often difficult to understand and complicated to use. A further criticism was that the differences between general purpose and aircraft standards were not sufficiently obvious. The Workshop Practice Handbook was also criticised and it was stated that serious difficulties arose due to discrepancies between information given in the Handbook and that contained in revisions of individual standards which had been published subsequently. It was agreed that the Handbook had proved extremely valuable in the past and had undoubtedly been among the principal means of introducing standards to industry; it was suggested, however, that the difficulty of keeping it up to date now that standards were frequently revised outweighed its former advantages considerably, and it ought not to be re-published.

There was considerable support for the view that the presentation of information should be simplified. The number of people in any one organisation now likely to be concerned with the application of standards made it essential that these should be readily understood and not too academic in approach. It was also important to remember that the standards should be intelligible to the many small users who had no standards departments to extract and interpret for them. There was wide support for the view that the publication of loose-leaf standards was desirable, although it was generally felt that they should take the form of data sheets supplementary to the present standards rather than supersede them entirely.

The meeting was accordingly asked to give detailed consideration to a proposal that B.S.I. should publish data sheets and the Chairman said that if a decision could be reached on that point alone the Conference would prove well worthwhile.

Publication of Data Sheets

Specimen data sheets for screwed fasteners, prepared for the occasion, were circulated and the Chairman of the Committee responsible for their preparation was called upon to introduce them. He referred to the statement issued with the data sheets in which it was explained that the original purpose of the Committee had been to formulate a comprehensive system of part numbering for screwed fasteners; events had led them to explore the possibility of associating the part numbering scheme with data sheets and the Conference was asked to keep their dual purpose in mind when reviewing the specimen sheets. He hoped that the Conference would also be mindful of the Committee's thought that data sheets of this type could be very valuable to small companies lacking the facilities to produce their own. He drew attention to the fact that the sheets had been printed at very short notice and it had not been possible to take account of several modifications which the Committee had already proposed; these included provision of a binding margin and the addition of standard lengths of bolts and screws.

Discussion on the subject was extremely animated and strong views for and against data sheets were expressed.

One objection to them was that B.S. data sheets could not be devised to suit the needs of individual organisations; standards engineers would still have the task of preparing their own and for this purpose they would prefer to go direct to the complete standards. It was further suggested that data sheets which attempted to summarise the contents of standards might discourage use of the latter and in many instances confusion might result.

Possibility of Confusion

The possiblity of confusion was referred to by another speaker, who said that data sheets of this kind were quite unsuitable for shop use, where all that was required was a simple drawing. Any standards engineer who adopted B.S. data sheets in addition to the complete standards would find himself with two sets of documents to keep up to date.

In reply to these objections, it was pointed out that whilst many companies might continue to prepare their own sheets for internal use, B.S. data sheets could save much duplication of effort; they could also facilitate communication between firms, with particular benefit to contractors who had often to deal with numerous data sheets from individual sources, all differing in some respects although they applied to the same article.

The Conference was reminded that British Standards were not intended solely for use by large organisations. A great proportion of industry consisted of small concerns with a hundred or fewer employees, where managing director and shop superintendent were often one and the same person. Such concerns had neither the means to buy a number of expensive standards, nor the time to make extracts of the information they required. Data sheets, by providing this information in convenient form at a reasonable price, would popularise standards among the smaller users and help to bring about simplification which was urgently needed.

Continental standards were cited as evidence of the advantages of this method of presentation. The Continental countries had all published their standards in this form for many years and it was unlikely to have persisted if their engineers had not found it satisfactory. But there were equally good examples nearer home; the British aircraft standards, which were in fact data sheets, were used throughout the aircraft industry and B.S.I. had also published a chart for the identification of Gas Cylinders and data sheets extracted from B.S.1916, Limits and Fits, all of which had proved successful. One speaker said that the B.S.1916 data sheets had enabled him to standardise a complete system of fits for his company's use, subject only to two additions.

The point regarding amendment slips was also felt to be worth reiterating; data sheets, it was submitted, could be completely revised and re-issued as and when required, thus eliminating the need for amendment slips which were regarded as a bugbear by all.

With regard to the form which data sheets should take, it was generally agreed that they should include as much essential information as possible since users would not wish to refer to numerous different sheets for any one item. The advantages of laminated plastic or other greaseproof material were referred to and the possibility of issuing wall charts was also mentioned.

After very full and frank discussion the majority opinion was that the publication of data sheets by B.S.I. was desirable. It was recognised that they could not entirely replace the present form of standard and that some standards would not lend themselves to this form of extraction; the Conference accordingly resolved that the British Standards Institution should publish data sheets as supplements to those standards from which extraction was appropriate.

CODE OF PART NUMBERS

The arguments for and against a standard part numbering system were similar in many respects to those put forward with regard to data sheets. The difficulties of formulating a truly comprehensive system were recognised. Coding, it was said, did not exist in a vacuum, but was an essential feature of standardisation. Various opinions were expressed on methods of identification and classification and on the desirability or otherwise of using part numbers as complete substitutes for descriptions.

So far as the proposed B.S. code system was concerned, it was explained that it had been envisaged as an adjunct to descriptions rather than as a substitute for them. It was intended to be simple and capable of being supplemented if necessary. A number of firms who had not formulated coding systems of their own had asked for guidance, and while it was recognised that many large organisations would continue to employ their own systems it was thought that they might adopt the standard code for external use.

Several of those present whose organisations had well-established systems of their own spoke in favour of a standard system, and said that there need be no difficulty in using the two with appropriate cross-references. A common code would help suppliers and contractors and all who had to deal with orders from many different sources. Reference was again made to the aircraft standards, which incorporated a complete part numbering system universally employed by British aircraft industry and its suppliers.

The general conclusion was that there was adequate support for the proposal that B.S.I. should consider the establishment of a standard coding system, suitable for use, where required, in conjunction with existing systems.

Conclusion

Before the meeting closed, two further proposals were put to the Conference: it was suggested that a Committee of standards engineers should be set up to advise B.S.I. on the application and implementation of standards, and that further Conferences should be held at intervals to be decided by the meeting.

Both proposals were fully supported and it was accordingly resolved to set up a committee on the lines indicated and to call another Conference in six months' time; subsequent conferences should be held only when there was material for discussion and it was agreed that it might usefully be left to the discretion of the committee to decide when conferences should be called.

The proceedings terminated with a vote of thanks to the organising sub-committee responsible for the Conference arrangements, and to the Chairman for his able conduct of the meeting.

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THE 1954 GEORGE BRAY

MEMORIAL LECTURE

"ENGINEERING AND PRODUCTION ASPECTS OF SYNTHETIC FIBRE MANUFACTURE"

by ROBERT DOUGLAS, M.B.E., M.I.Prod.E.

Presented to the Institution at a meeting of the North-West Region in Manchester, on 18th April, 1955.

Mr. R. Douglas.

Mr. Douglas is a Lancashire man of tradition and humour, whose active appointments indicate the measure of his personal force. He is Technical Director of Textile Machinery Makers, Ltd., the group of Lancashire textile machinists; Chairman of Dobson & Barlow, Ltd., Bolton; Deputy Chairman of T.M.M. (Research) Ltd., Helmshore; and a Director of the following companies: Platt Bros. (Barton) Ltd., Manchester; J. Hibbert & Co. Ltd., Darwen; Dobson & Barlow (Rayon Plants) Ltd., Bombay; N.M.M. Ltd., Bombay; and Platt Bros. (Sales) Ltd., Oldham.

He has made swift progress within the textile engineering industry from humble beginnings—his father was a machine shop foreman with Dobson & Barlow in Bolton, where Mr. Douglas started as a shop apprentice at the age of 14. Graduating as a skilled outfitter, at 21 years of age he was placed in complete charge of the erection and starting-up of a rayon spinning plant. At 25 he was appointed Technical Manager with a firm of rayon spinners in Brazil—F. Matarazzo—remaining in this position for four years before taking up an appointment as Production Manager with the Transparent Paper Company, Ltd., in Bury, Lancashire.

In 1941 he became Production Manager of Dobson & Barlow, Ltd., and was elected to the Board in 1945. Two years later he was appointed Managing Director and, in the same year, Production Director of Textile Machinery Makers, Ltd.

THIS Paper is concerned with some of the engineering and production problems associated with the introduction of a new branch of the textile industry, or engineering as applied to a chemical process.

In the title of the Paper, the word "synthetic" is used in a very broad sense and might well be replaced by "man-made". Although it is of comparatively recent origin, the field of the man-made fibres is already considerable, and in a short Paper an Author must either deal with all the man-made fibres and treat each concisely and somewhat inadequately, or select a representative fibre and deal with it in detail. In this Paper, the latter course will be followed, and rayon, and in particular viscose rayon, will be taken as representative of the field.

It is advisable to stress the fact that the Paper is concerned primarily with engineering problems and that the associated chemical processes are dealt with only in sufficient detail to make the engineering problems clear. As a necessary background, the origin and commercial development of rayon will be outlined, statistics indicating the growth of ravon production and its tremendous importance in world trade will be given, and the remainder of the Paper will be devoted to the engineer's endeavour to convert laboratory apparatus and conceptions into commercial realities. It will be appreciated that the conversion of facile laboratory schemes into large-scale plants presents many difficult problems, especially when consideration is given to capital and maintenance

costs, labour utilisation and the compulsory treatment and disposal of effluent.

In the production of synthetic fibres, it might well be asked: "Where does the chemist finish and the engineer start?". There is no clear division of responsibilities. Obviously, the scientist or chemist must first conceive the process and lay down the formulae to which the engineer must work, but from there on it is only the combined effort of scientist and engineer which can create a successful plant and product.

Origin and Commercial Development

The possibility of devising a method and apparatus for the production of "artificial silk" exercised men's minds for some two hundred years before the first commercial rayon was produced.

In the field of textiles, many brilliant ideas had been conceived long before the means were available to put them to commercial use, and it is remarkable that as long ago as 1664, Dr. Robert Hooke suggested that a way might be found to make "an artificial glutinous composition" resembling the substance produced by the silkworm, and to draw out this composition in the form of a fine thread. In the 18th century, Reaumur suggested that silk might be simulated by forcing gums or resins through fine orifices.

It is also characteristic of the field of textiles that the ultimate commercial success of many an invention has required a synthesis of related developments. Thus the production of rayon on a commercial scale was dependent upon Keller's discovery, in 1840, of a method of producing wood pulp, and also on the development of the spinneret by Schwabe and Ozanum in the 1860's.

In the meantime, Schoenbein had originated nitrocellulose, or gun cotton, which was to form the basis of the first commercial rayon; and Audemars had produced a species of collodion by dissolving nitrocellulose in alcohol and ether, from which combination he formed fine filaments. To Audemars belongs the distinction of taking out, in 1855 in England, the first known patent for the production of rayon. His process was not, however, commercially practicable.

One further item of research in another field was required, before the first commercial rayon appeared. Sir Joseph Swan, searching for an improved electric lamp filament, produced a continuous homogeneous thread by forcing nitrocellulose, dissolved in acetic acid, through a small hole into a coagulating bath of alcohol. By treating the thread with ammonium sulphide, the cellulose was regenerated and the nitrate neutralised. Swan obtained a patent in 1883, and clearly realised that his filaments might be used for textile purposes. Samples of the filaments, together with table mats and doilies crocheted by Lady Swan, were exhibited in London in 1885 and described as being made of "artifical silk".

The first to produce and market rayon on a commercial scale was Count Hilaire de Chardonnet. He studied chemistry and diseases of the silkworm under Pasteur, and his interest in photography and the accidental breaking of a bottle of collodion drew his attention to the possibility of making filaments which closely resembled silk. After nearly thirty years of research, he developed a practical process for the production of continuous filaments from nitrocellulose dissolved in ether and alcohol, extruded through the fine holes of a spinneret, and coagulated by evaporation of the solvent. Soon after a French patent was granted to him in 1884, Chardonnet built a plant at Besancon to produce his new "man-made" yarn. In England, the process was taken up by Wardle and Davenport who, in 1899, also established a rayon factory at Tubize, Belgium. In 1920, the Tubize Company established a plant in the United States. Nitrocellulose or "Chardonnet" rayon was successful for some thirty years, but then gave way to other types.

The next successful method of manufacturing commercial rayon was the cuprammonium process; and this again was the outcome of the work of several men, beginning with Schweitzer's discovery, in 1857, that cotton could be dissolved in ammoniacal copper hydroxide solution. In 1882, Weston produced electric lamp filaments, by treating cotton with cuprammonium solution, and in 1890 a French patent was granted to Despeissis for the production of textile yarns by the cuprammonium process. Within the next decade patents were issued to Bronnert, Pauly, Urban and Fremery, and these patents were worked by the Vereinigte Glanzstoff-Fabriken company in Germany. Cuprammonium rayon was so successful that a manufacturing licence was soon taken out by a French company, and by United Cellulo Silk Spinners Ltd. of Great Yarmouth. At about the same time, a British subsidiary of the Glanzstoff Company was established, and in 1919 Brysilka Ltd. commenced production with the spinning equipment of the old United Cellulo Company. In 1931, British Bemberg Ltd. commenced the spinning of cuprammonium yarns at Doncaster. In spite of its many excellent qualities, however, cuprammonium rayon has been greatly overshadowed by its viscose and acetate rivals.

The third method of manufacturing rayon has proved to be by far the most successful. This was the viscose process, by which the great bulk of the world's rayon is now manufactured. Because of the overriding importance of this process, it is here proposed to deal next with the fourth method—cellulose acetate—and to leave the viscose process for subsequent, more detailed, explanation.

The fourth successful rayon was cellulose acetate, which today ranks second only to viscose in volume of consumption. It is interesting to note that the first patent for the manufacture of filaments of cellulose acetate was granted in 1894, to Cross and Bevan, the discoverers of the viscose process, and that once again the primary object was the development of an improved filament for electric lamps.

Cross and Bevan adapted a chemical process that had been discovered by Naudin and Schutzenberger in 1869: this was to dissolve cellulose in acetic acid,

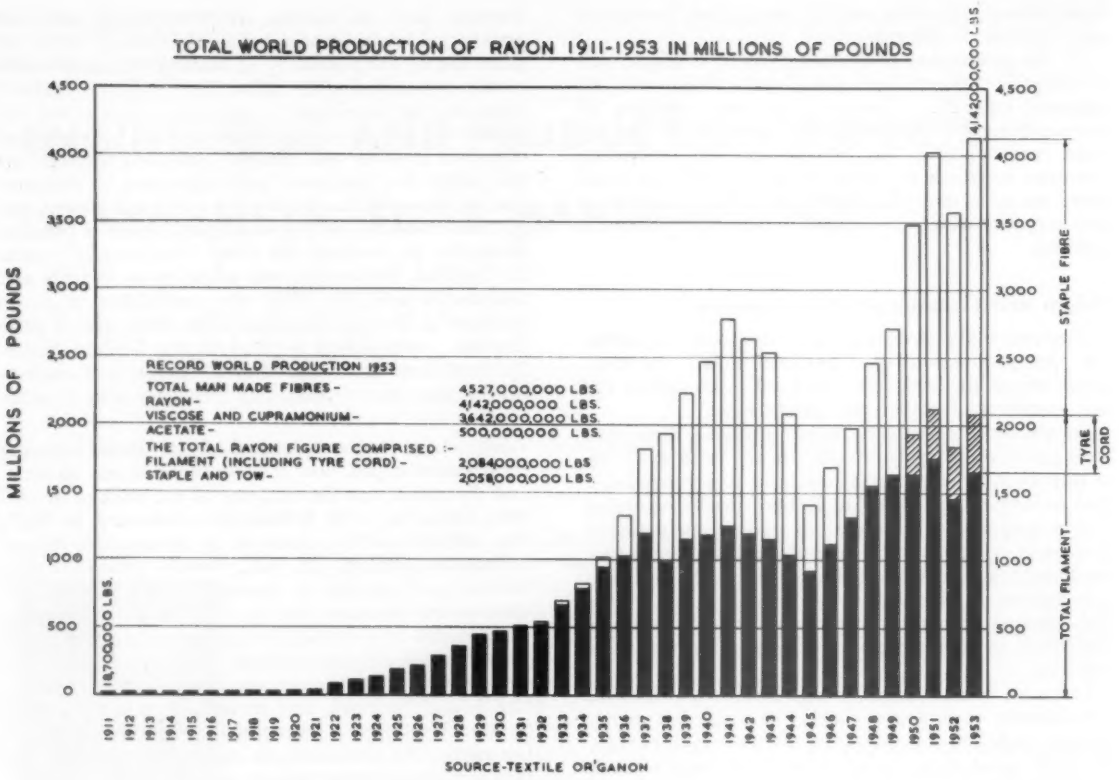


FIG. 1

leading to the formation of cellulose acetate as a chemical compound. Subsequently, it was found that zinc chloride or sulphuric acid catalysed the chemical reaction. Bronnert, who contributed so much to the development of cuprammonium rayon and also assisted Chardonnet to improve nitrocellulose rayon, produced cellulose acetate filaments at Mulhouse in 1899.

The most important research into the use of cellulose acetate for textile purposes was conducted by Little, Walker, and Mork in the United States, and by Henri and Camille Dreyfus in Switzerland and England. Acetate rayon is now manufactured by many firms, but it will no doubt always be associated with the name of the Celanese Company. Acetate differs from the other three types of rayon in that, whereas the latter are based on processes for the regeneration of cellulose, acetate is a chemical combination of cellulose with acetic acid. It should also be noted that acetate filaments are coagulated or hardened in warm air and not in a liquid-coagulating bath.

The Viscose Process

Returning to the viscose process, this was largely the work of Cross and Bevan, specialists in the field of the chemistry of cellulose, and of Stearn and Topham who were concerned with the development of filaments for electric lamps. Stearn worked with Sir Joseph Swan, who contributed so much to the discovery of nitrocellulose rayon. Cross and Bevan, working with an associate named Beadle, discovered that if cellulose is treated with caustic soda, and subsequently with carbon bisulphide, it is converted into an entirely new compound which dissolves in water or dilute caustic soda solution to give a thick, straw-coloured solution, having the viscous consistency of golden syrup. Because of this characteristic, they named their discovery "viscose" and secured a patent on their process in 1892. They sent a sample of their product to Stearn, who realised that it might make useful textile filaments and asked Topham to devise a method of spinning. From this point, the successful development of the viscose process owed a great deal to Topham's doggedness.

In the course of many experiments, he discovered accidentally that it was essential to give the viscose solution sufficient time to ripen or age, and he built a spinning apparatus including a precipitating bath to harden the filaments. Subsequently, he turned his attention to the making of a better spinneret and produced a multiple hole platinum cap to which he added a filter to strain foreign matter from the viscose. Another improvement he made at this time was a viscose mixer, which is still in use in some rayon producing plants. He also hit upon the idea

of delivering the hardened filaments into the interior of a fast revolving pot. This is by no means a complete list of Topham's inventions in the viscose field, but sufficient has been said to indicate the magnitude of his contribution to its development.

In the early 1900's, manufacturing licences under the patent of Cross, Bevan, Stearn and Topham were taken up in Britain and the United States. The British rights were acquired by the firm of Courtaulds, who spun their first viscose yarn at Coventry in 1905. Plant for the production of viscose rayon on a large commercial scale was manufactured by Dobson & Barlow Ltd. in 1902 to 1905.

Growth of Production

The enormous value of these new fibres in the world textile industry and their rapid growth are illustrated by the statistics quoted later. The impact of these "man-made" fibres has been felt in many other branches of industry, especially in engineering and who can say that it has not enhanced the attractive appearance of the female sex ?

It must be noted that the bulk of this production has been of continuous filament as originally conceived by the process introduced by Cross & Bevan in 1902, but about the year 1925 the textile industry had its second impact due to the blending of rayon with natural fibres such as cotton and wool. This brought about the introduction of a new range of very attractive dress and furnishing materials, but in its accomplishment it was necessary to alter the form of the rayon yarn.

Staple Fibre

Natural fibres comprise staples of varying lengths, but rayon is spun on an extruding machine in continuous filaments and, in order to blend the materials on machines designed for processing natural fibres, it was necessary to cut the continuous filament rayon into staple lengths consistent with the length of staple of the natural fibres with which it was to be blended. As cut staple rayon fibre was required by the textile mills in bale form, it was obviously more economical to produce the rayon in the form of a thick rope or "tow" rather than as a yarn. This necessitated the design of a new type of machine with resultant production problems.

New Uses

During the Second World War, Germany had difficulty in obtaining cotton with which to make the cord fabric for motor car tyres and, as a result, experimented successfully with heavy rayon yarns, which have since been practically universally adopted throughout the world.

This created yet another problem for the textile engineer, and resulted in the design of a further suitable new machine.

Statistics

It is not proposed to go back further than 1911 to illustrate the impact of these new synthetic and man-made fibres on the world's textile market, and the graph in Fig. 1 shows the growth of production from that year until 1953. The black portion represents continuous filament yarn, the open portion staple fibre, and the shaded area indicates tyre cord.

These figures show that in 1953 the world's production of rayon was approximately 4,500 million pounds, and if this figure was related to the world population, it would average a consumption of approximately 2 lb. of rayon per person. It could be argued that this must have had some effect on other textile fibres, and it is interesting to note that in 1911 the average consumption of cotton per person was 7 lb., whilst in 1953 it was 7.2 lb. Although these figures are not truly comparable, it is reasonable to assume that the advent of rayon has not affected the consumption of the major textile fibre.

Apart from speciality plant, which will be described later, the production of rayon calls for many standard engineering products, and in 1953 the world production of rayon demanded the following services :

Electricity	1,200,000 KWH/hr.
Water	42,700,000 galls/hr.
Steam	23,000,000 lb./hr.
Treated Water ...	16,700,000 lb./hr.
Refrigeration	92,000 tons/hr.

The labour demands for this production would be approximately 500,000 persons, including highly skilled scientists, chemists, technicians and civil, mechanical and electrical engineers.

The production of these new fibres, to the extent mentioned, necessitates the use of the following plant :-

Caustic Soda
Sulphuric acid
Carbon-bisulphide
Caustic recovery
Acid recovery
Carbon-bisulphide recovery
Effluent treatment
Exhaust fume treatment
Instrument makers
Air-conditioning and ventilating
Compression and vacuum pumps
Laboratory equipment
Laundry machinery and many other types of engineering.

In the production of the speciality plant required, and the plant mentioned above, the following metals and materials are included :-

Platinum; Gold; Tantulum; Monel; Cast iron; High grade stainless steel; Tungsten carbide; Various common steels and alloys; Pure chemical lead; Brass; Copper; Phosphor Bronze; Pure Nickel; Glass; Aluminium and its alloys, including 99% pure aluminium.

From the above figures it will be seen that this new textile fibre has called for many branches of the engineering and metallurgical services.

Process for Producing Viscose

Viscose rayon is a regenerated fibre, in that it is made by dissolving cellulose and converting it back to a solid. The basic material from which it is produced is wood pulp, in the form of bleached sulphite pulp sheets made from spruce.

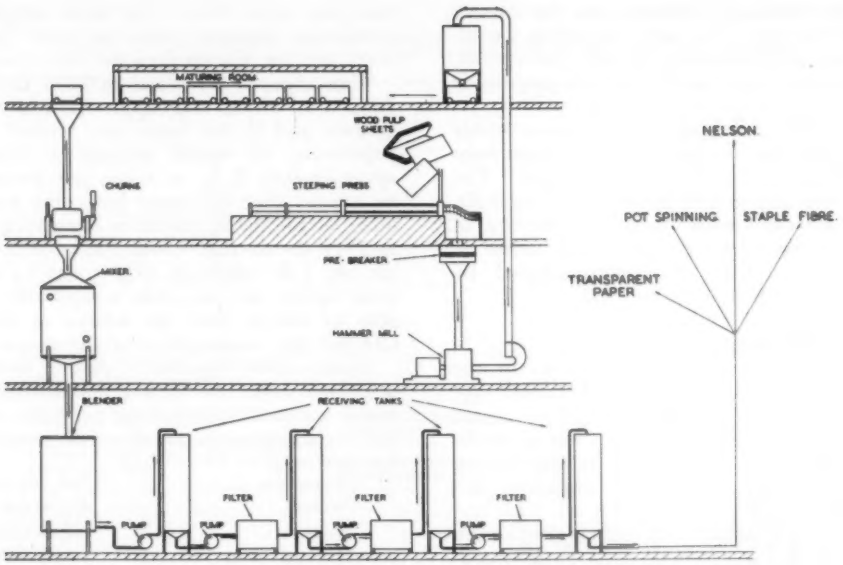


Fig. 2. Diagrammatic flow plan of viscose plant.

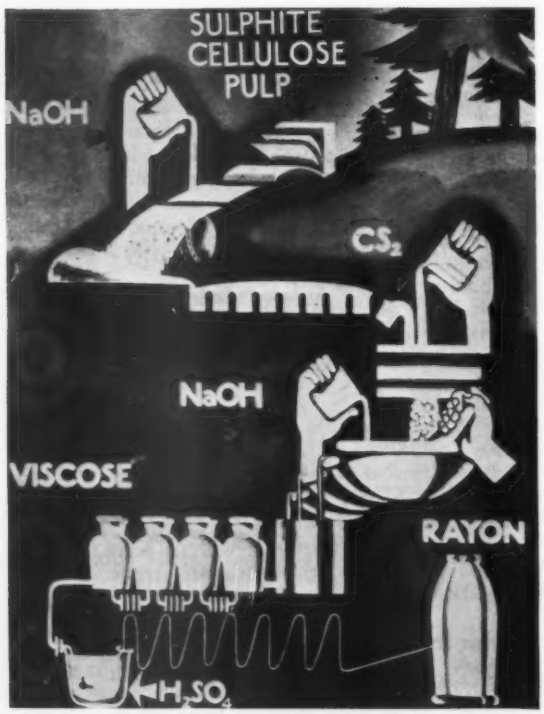


Fig. 2 (a). Artist's impression of viscose producing process.

The process transforms the pulp into an alkaline viscose solution which is extruded into a dilute solution of sulphuric acid forming a cellulose thread. Fig. 2 (a) is an artist's impression of the process, which shows the spruce trees from which the bleached sulphite pulp sheets are produced. The pulp is then steeped in a caustic soda solution where the beta and gamma fractions of the cellulose in the pulp are dissolved. The pulp is pressed to remove the excess solution, which carries with it most of the unwanted hemi-cellulose, (beta and gamma cellulose), leaving an alkali cellulose containing approximately 30% alpha cellulose, 12% caustic soda, a trace of hemi-cellulose and water. The pulp sheets of alkali cellulose are then transferred to a disintegrator, broken down to a form of particles similar to bread crumbs, and then transferred to a temperature controlled chamber for a period of maturing. The molecular structure of the cellulose splits to a form which will regulate the viscosity of the subsequent viscose.

After a specified time, the alkali cellulose is transferred to a revolving drum called a churn, where it is treated with carbon bisulphide to produce a xanthate cellulose, which is a product soluble in a caustic soda solution. The xanthate cellulose is then dissolved in a mixer, in which a homogeneous solution called viscose is formed. This solution will have approximately 7% cellulose and 6% caustic soda, and from this point various stages of blending, filtration, and ripening take place until the viscose, after de-aerating, is in a fit condition to be extruded through fine holes of a jet into a coagulating bath of dilute sulphuric acid. The coagulation and setting of the rayon filament, as it now becomes, quickly takes place, and the yarn is wound on to a suitable package for after-

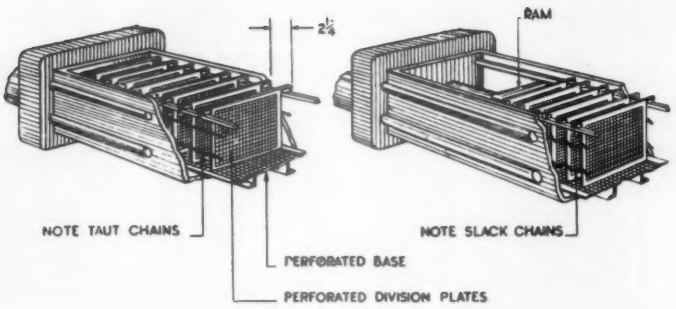


Fig. 3. Wood pulp steeping press.

treatment to remove the residual sulphur, followed by bleaching, and the addition of a softening agent.

Engineering the Process

It is unnecessary here to describe the production of the sulphite bleached cellulose sheets from the spruce tree. This is a refined process of the normal paper pulp production and is an old and established industry which is well known. We may commence with the supply of the pulp in sheet form to a rayon plant. (See Fig. 2).

Steeping and Pressing

Throughout the process, the control of weight, temperature and time are most important. The sheets of wood pulp, on arrival at the factory, are stored in order that they may be conditioned to a predetermined moisture content. The first stage of manufacture is to steep a predetermined weight of sheet pulp in a caustic soda solution. This steeping is effected by immersing the sheets of pulp in an upright position in a special steeping press—see Figs. 3 and 3(a), in which the sheets of pulp are separated by division plates constructed in the form of a sandwich, consisting of two outer perforated plates and an inner sheet of strong metal gauze. This allows the liquor to penetrate more effectively to the whole surface of the sheet of pulp, and also allows it to be more evenly pressed out.

The steeping tank forms part of a hydraulic press, one end being closed by the head of the ram and the other by a sluice gate or door, operated by hydraulic pressure. The pulp sheets swell considerably in the steeping press and absorb caustic soda very freely. At the end of the steeping period, during which complete saturation has taken place, the ram is moved up to a position in which the sheet pulp will be supported in its upright position and the free liquor is run off to be returned to the circuit from whence it came. The ram head is now advanced to remove a definite proportion of the remaining liquor, and at the same time a large amount of the hemi-cellulose is extracted in suspension in the liquor.

The liquid from this second pressing, being too rich in hemi-cellulose, cannot be returned directly for re-use. It is, therefore, treated by a dialiser to recover the caustic soda, in order that it may be used again.

Pressure is now released from the pulp and the door at the end of the tank is raised to create a free exit. The ram is again advanced to push the steel plates and the pulp held between them through the end of the tank. The plates are held above an awaiting steel truck and the sheets of alkali cellulose are made to drop into the truck for transport to the next process.

The steel plates are now retracted into the press by reversing the ram, the hydraulic door is lowered, and the press is now ready to receive the next charge of pulp.

The weight of alkali cellulose at this stage should be approximately three times the original weight of wood pulp.

It will be appreciated that the mechanical problems in the design of the steeping press are the general stressing of the tank, door, and separator plates and the need for a three-speed servo-controlled hydraulic ram, approximately 23 feet long, with a fast return.

Disintegration

One method of disintegrating the pulp is by passing it through a controlled feed pre-breaker and thence through a hammer mill which is illustrated in Figs. 4 and 4(a). The particles or crumbs are then removed by air flow to a convenient point where a cyclone separator deposits the crumbs into containers

Fig. 3(a). Wood pulp steeping press.

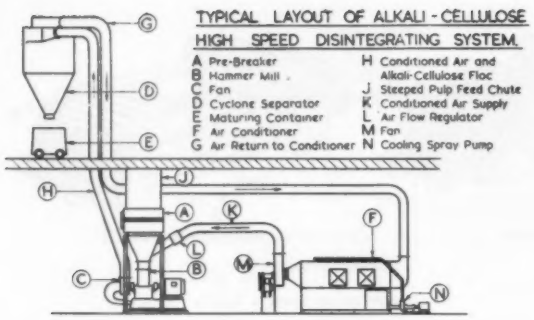


Fig. 4. Line diagram showing high speed disintegration system.

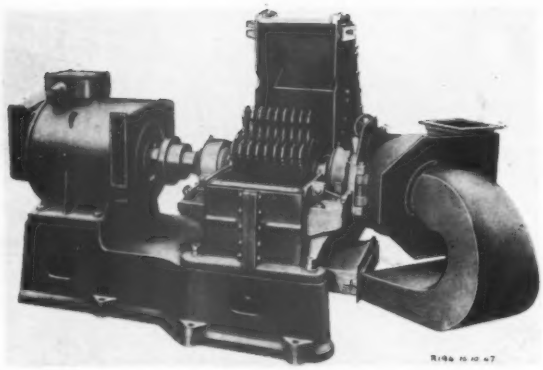


Fig. 4 (a). Photograph of hammer mill.

ready for maturing. The pre-breaker, hammer mill and separator are standard equipment but are fitted with a special arrangement to ensure a constant feed. The peculiar problems at this stage are to stop any drying of the crumbs, maintain a pre-determined temperature and not allow any carbonation to take place, and easy cleaning. This is achieved by installing a closed air circuit between the hammer mill and separator, with easy access by special airtight doors, To prevent the alkali cellulose from drying, the air is temperature controlled at dew point humidity and washed with a soda solution which helps to prevent carbonation.

Maturing

Maturing of the crumbs takes place in a temperature controlled room, which offers no particular problems to a ventilating engineer. The maturing time and temperature control is of primary importance. Room temperature control is maintained at + or $-\frac{1}{2}$°C at any point of the room.

Churning

The churn to which the matured crumbs are now taken—shown in Figs. 5 and 5(a)—comprises a water-jacketed cylinder fitted on trunnions through which are placed a water feed and return to and from the jacket, and a carbon bisulphide feed to a spray pipe inside the body of the churn

The churn revolves very slowly, i.e. about 1.0 r.p.m., allowing the crumbs to tumble during its rotation, and a measured quantity of carbon bisulphide, having been run into a measuring vessel, is now allowed to flow by gravity into the spray pipe, thereby allowing the carbon bisulphide to vaporise and penetrate into the crumbs. This is arrested by creating a vacuum inside the body of the churn.

The temperature inside the churn is maintained at approximately 26°C by means of the water jacket. Apart from the two feeds through the trunnions previously mentioned, there is another feed to a vacuum pump, which comes into operation at the end of the churning period to extract the fumes prior to opening the churn door for discharging the crumbs.

The timing of this operation is very important, and a sight glass window is fitted in the body of the churn through which the chemical reaction is watched as the crumbs gradually turn from white to yellow and finally to an orange colour—the period being about two hours. The fumes from carbon bisulphide are injurious and it is therefore essential that all joints on the machine and on pipe lines leading to the machine should be perfectly sealed, and regularly inspected. The carbon bisulphide is stored in special steel containers immersed in water, and located outside the main factory building. From these is it transferred to the measuring vessel on the churn by

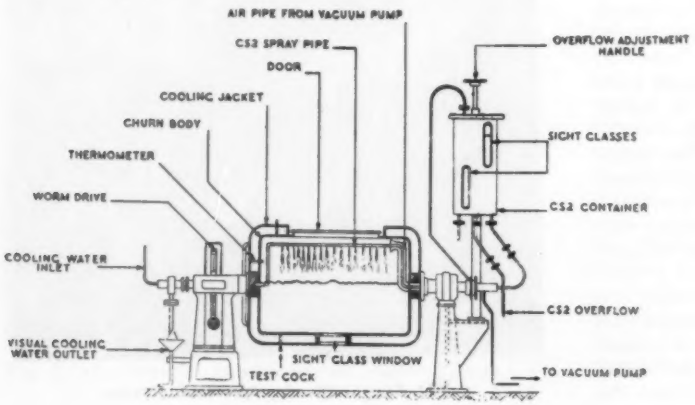


Fig. 5. Horizontal churn.

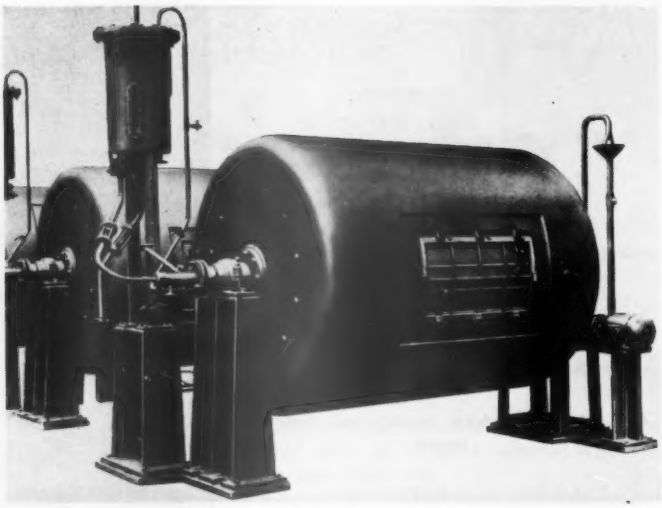


Fig. 5(a). Horizontal churn.

water pressure. As fire risks are very high, due to the presence of carbon bisulphide, all motors and switchgear are of a completely protected type and are usually isolated from the churn by placing them in an adjoining room. It is also necessary to have frequent air changes in the churn room.

Mixing and Dissolving

The crumbs of sodium cellulose xanthate are now of such a nature that they are soluble in a caustic soda solution. This process is carried out in a large capacity mixer of a design specially adopted to deal with the heavy glutinous substance into which the crumbs are to be transformed.

The designer's problem can be understood when it is realised that a 45 h.p. motor is required to drive the impellor of the mixer at a speed of 130 r.p.m. The vessel seen in Figs. 6 and 6(a) is again a jacketed one, which enables the temperature to be controlled. The xanthated crumbs are gravity fed into the top of the mixer and an inlet is provided for the addition of a caustic soda solution. The objects of this machine are to dissolve the crumbs and to mix the resultant solution. To achieve these objects, the shallow impellor of the mixer is circumscribed by a perforated steel ring fitted with a top shroud, thus providing the tearing action for breaking up the crumbs. The action of the paddle is such that the liquor and crumbs are forced outwards through the perforated steel ring and then up the sides of the vessel to pour inwards to the centre, thus creating a vortex. This operation gives efficient dissolving and mixing which takes about 1¾ hours, after which the viscose is assisted through the outlet valve by the action of a pump. This pump can, if necessary, be used to assist the circulation of the solution during mixing. The major design problem was the bottom drive to the impellor, necessitating a special type of gland, as no bearings are carried in the body of the mixer.

The correct consistency of the viscose is checked during each batch for chemical analysis and viscosity.

Blending

In order to minimise the variations of the different batches of viscose, a blender is introduced to which the viscose is pumped from each of the mixers. This machine is a much larger and more simple type of mixing vessel which holds three or four charges from the mixers previously described.

The blending achieved is most efficient as a result of the procedure employed, which introduces one new mixer batch for every blended one removed. Thus we have five different batches or charges being blended at any one time.

Ripening and Filtration

The preparation of the viscose solution having been completed, it is now necessary to filter out all impurities and to allow it to ripen over a period of

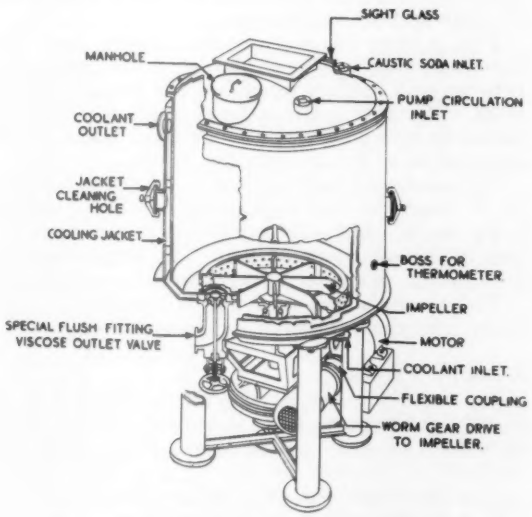


Fig. 6. Turbine mixing and dissolving vessel.

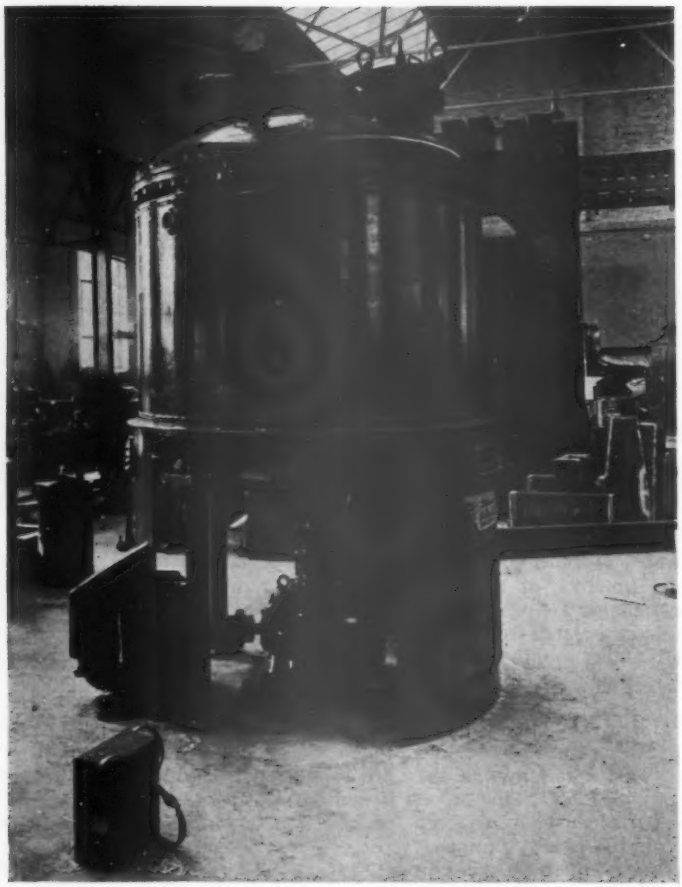


Fig. 6(a). Turbine mixing and dissolving vessel.

time and eventually to extract any air or gases from the solution prior to spinning.

This is done by pumping the solution from the blender through a series of four batches of containers, between each batch of which it passes through a filter press. The final group of tanks serves to allow the viscose to settle and be vacuum treated ready for its presentation to the spinning machines.

The number of tanks utilised in this room depends on the length of time necessary to ripen the viscose to the degree which will permit it to coagulate in the bath of the spinning machine. The temperature of the ripening room has to be accurately maintained.

The viscose is now ready to be transformed into rayon continuous filament, or staple fibre.

Spinning Process

The transformation of the viscose liquid into a thread is effected on what is termed a spinning or extruding machine. There are three types of machines in common use :-

1. a centrifugal pot spinning machine;
2. a parallel bobbin spinning machine;
3. a continuous process machine.

The viscose is fed under pressure and distributed to a number of points along the machine, whence it passes through a metering pump and filter to a multi-holed jet. By this means, the viscose is extruded into a bath of dilute sulphuric acid where it coagulates, leaving a cellulose thread containing sulphur and liquor from the spinning bath. The cellulose in this thread is approximately equal to the amount of alpha cellulose contained in the original wood pulp.

The acid liquor and sulphur deposits on the thread must be removed by subsequent treatment. A gas, sulphuretted hydrogen, is liberated and must be extracted from the working area of the machine. Finally, a large amount of water is freed into the bath and this gives rise to the necessity for an acid recovery plant.

A diagram showing the transformation of viscose into yarn and its subsequent passage through the spinning machine is shown in Fig. 7. The cellulose thread is immersed in the acid bath for a predetermined time and is then wound round two glass godet rollers, the second of which runs at a slightly increased peripheral speed to provide stretch. The

yarn is then guided through a traversing glass funnel and is deposited into a revolving spinning pot, forming a package known as a cake.

Some very interesting engineering problems were encountered in the development of this machine, the first being presented by the metering gear pump. The delivery from this pump controls denier or weight per unit length of the yarn, which can be varied by increasing or decreasing the pump speed by means of gear changes in the main head-stock, and also by adjusting the speed at which the thread is drawn away from the jet.

As the denier of the yarn to be spun must be maintained within very fine tolerances, it is necessary that the pump should be a high precision unit and, due to the composition of the viscose, it is essential that a very careful study should be made of the materials used in its construction.

The main body of the pump is made of a special quality cast iron, and the three plates it contains and the two wheels which fit in the centre plate to form the metering mechanism are made of stainless steel, hardened and tempered.

A special feature of the unit is the provision of means in the pump for using the viscose it meters as a continuous lubricating medium for the pump wheel shaft. This self-lubrication prevents any contamination of the viscose, as would be the case if an extraneous lubricating medium was used. As the metering pump is made to give an accurate regulated flow with a varying input pressure and output back pressure, no adjustments can be made after assembly.

The concentricities of the bore of the wheels to the outside and pitch circle diameters is of paramount importance and the final grinding of the bore is done after the teeth have been ground, the location being made from the pitch circle of the teeth. The plates and the wheels are lapped and honed to a tolerance of .0002".

In order to prevent a blockage of the holes in the jet, the viscose, after leaving the pump, is passed through a final filter and thence through a tube carrying the jet.

The jet provided one of the most interesting problems in the manufacture of rayon yarns, and samples, etc., must be seen for this to be fully appreciated The jet has a number of holes in its base, which may vary from 30 to 100 depending on the number of filaments contained in the final structure of the yarn, and these holes vary in diameter from .0032" to .0035". The jets are subjected to both alkaline and acid reactions, the viscose containing caustic soda on the inside, and the bath containing sulphuric acid on the outside.

In the early days of rayon production, glass jets were used, but they were too clumsy and easily broken, and the holes could not be made as perfect in shape as was necessary.

Pure platinum, tantulum and alloys of these, gold, and other rare metals are now used, and apart from being the most expensive single component on the spinning machine, the jet is the most vital.

Due to the corrosive nature of the dilute sulphuric acid, the coagulating bath is lined with pure chemical lead or other acid resisting material and parts of the machine that are liable to be contaminated with the acid spray, are also protected.

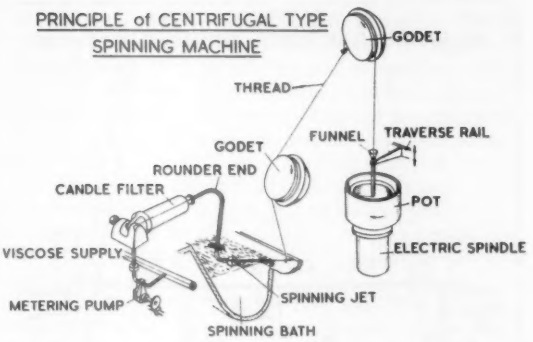


Fig. 7. Basic diagram of centrifugal pot spinning process.

The process up to the end of the immersion in the acid bath is common to all three forms of spinning.

Parallel Bobbin Spinning

The parallel bobbin method takes the thread from the spinning bath and by means of a traverse, winds it on to a parallel perforated bobbin of about 6" diameter, 8" long. This method winds the yarn in an untwisted form, but in a manner in which it can easily be treated by subsequent operations for the removal of acid and sulphur deposits preparatory to drying.

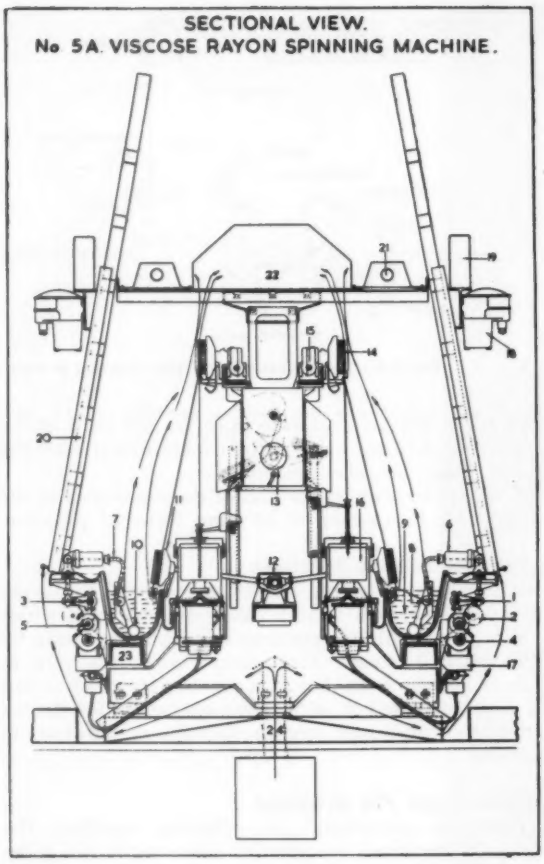
Centrifugal Pot Spinning

On the centrifugal pot spinning machine, the yarn as previously described is taken round two godet rollers and from there fed through a glass funnel into a spinning pot revolving at high speed.

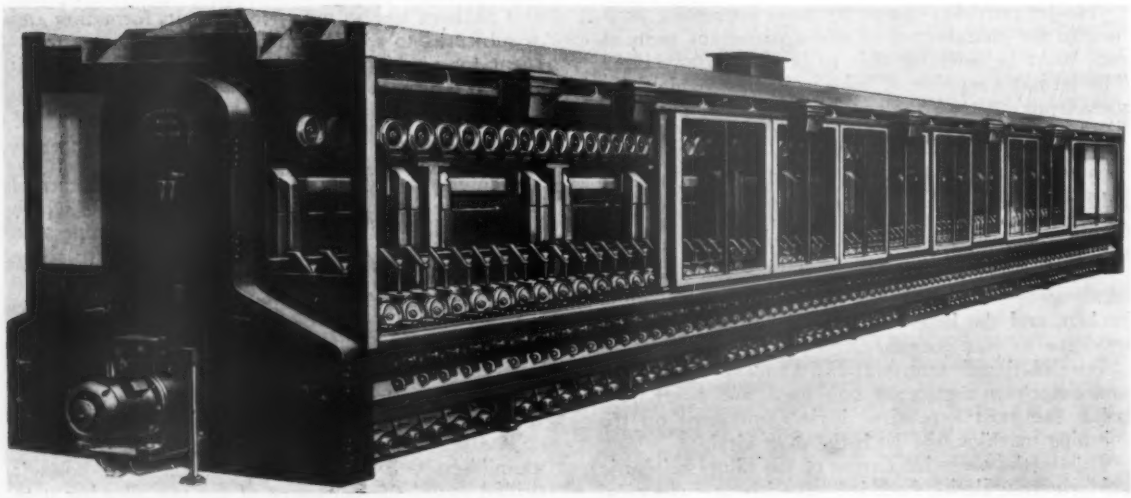
As with parallel bobbin spinning, the centrifugal pot spun yarn is in a "wet" state and must have a similar form of after-treatment, excepting that in this case twist has already been inserted and therefore the twisting process is unnecessary. Considering that this package has no support except its formation and is subjected to some form of pressure in later treatment for washing, desulphurising, bleaching, etc., it is necessary that the package should be of a form which is well knit together but at the same time allows a reasonably free passage of liquids from the inside to the outside.

The glass funnels previously mentioned are carried in bakelite holders on pure aluminium rails which are controlled by the reciprocating traverse operated by a cam mechanism. This permits the yarn to be deposited inside the spinning pot in the form of a helix. During the building of the package or so-called "cake," there are periods when the yarn would tend to build up in one position and, to prevent this, a mechanism is introduced to disturb the throw of the traverse thereby permitting an open wind of the yarn.

The spinning pot is 6" diameter and made of pure aluminium or bakelite. A series of small holes is drilled round the periphery of the pot allowing it to



Figs. 8 and 8 (a). Centrifugal pot spinning machine. 1. Viscose feed pipe; 2. Wheel pump; 3. Pump holder; 4. Main pump shaft; 5. Auxiliary pump shaft; 6. Candle filter; 7. Glass rounder end; 8. Spinning jet; 9. Acid bath; 10. Acid feed pipe; 11. Bottom godet; 12. Bottom godet drive; 13. Traverse motion; 14. Top godet; 15. Top godet drive; 16. Spinning unit; 17. Electric spindle plug; 18. Group switch for spindles; 19. Bus bar chamber; 20. Sliding windows; 21. Fluorescent lighting; 22. Fume hood; 23. Trough beam; 24. Fresh air inlet; 25. Fume removal duct.



be used as a hydro extractor, by throwing out the excess acid that has been carried into the pot with the yarn, as well as being the container in which the cake is formed. The spinning pot will run at speeds up to 10,000 r.p.m.

Each pot is driven by its own electric motor, and as each package or cake is completed, it is necessary to take the pot from the motor spindle in order that the package of rayon can be removed and, due to the nature of this process, the spindle must be designed to accommodate an out-of-balance load. Various methods for accomplishing this have been designed, but in general a flexible spindle fitted in a motor with a resilient rubber seating accommodates the out-of-balance load and allows the spinning pot to find its own centre of gyration.

The whole of this electric spindle unit is fitted inside a casing, which is so designed as to protect the motor from acid spray and also to collect the acid and drain it through an overflow pipe. The casing also controls windage round the spinning pot thereby reducing the power consumed. In the event of a fault developing in the electric motor or spindle, it is possible to replace the complete unit in a few minutes. The importance of protecting all mechanism from acid spray must again be emphasised, but of equal importance is the protection of the operator from spray and fumes. To accomplish the latter, sliding windows are fitted to the machine to isolate the acid-contaminated area and the fumes, thus being localised, are extracted through a duct running the whole length of the machine. Fresh air is allowed to enter under the machine to replace the fumes extracted. By a perusal of the photograph and cross section shown in Figs. 8 and 8(a), it will be appreciated that the engineer has had many headaches in producing such a machine at a reasonable price.

After-Treatment of Cakes of Rayon Yarn

The cakes of yarn produced by the centrifugal pot spinning machine which has just been described may be processed by two methods, known as cake washing and hank washing. The first of the processes is preferred because of the reduced handling of the packages of yarn. The second process, which is the older, was necessary in past times, because it gave a more efficient treatment to the yarn. It has, however, been superseded by a cake treatment as a result of the far superior building of the package which is achieved by the traverse and differential mechanisms on the centrifugal pot spinning machine. The permeability of these cakes is so regulated as to permit pressures of up to 20 lb./sq. in. to be used, with resultant highly efficient treatment.

Although a large amount of the spinning bath liquid is removed by the centrifuging effect of the spinning pot, some does remain. This is first washed away and then de-sulphurising solution is forced through the cake to remove residual sulphur which adheres to the threads. Again, the cake is washed prior to a bleaching solution being applied with its accompanying wash.

In the pressure washing process, the cakes are mounted on perforated metal formers after having been wrapped in a stockinette material. These formers have a single flange which seals off one end of the cake and as it sits on the end of another cake, it seals that off also. These formers are built up on a perforated column and a screw pressure is applied to make the sealing effective against the pressure of the fluids which are to be forced through the cake from the inside. This column of cakes is coupled to a union through which the various treatment liquors are now forced. Due to the various corrosive properties of the different liquors, materials of high grade quality stainless steel are used.

After the bleaching process, the cakes are put into a hydro-extractor and all excess liquor is removed centrifugally.

The cakes are now dried and are then ready to be delivered to factories where after processes take place such as dyeing, knitting, twisting, weaving, etc.

Continuous Process Machine

The pump unit, filter jet and coagulating bath are similar to those employed in the two other types of spinning machinery previously mentioned.

The general process from the coagulating bath to the twisted dry yarn is shown in Fig. 9, and a full view of the machine can be seen in Fig. 10.

The yarn is taken from the bath, stretched, and threaded round two rollers, one placed above the other. These rollers are arranged at right angles to the length of the machine, and are set a little out of parallel and, offset axially, thereby allowing the thread to traverse across both rollers in a helical path. The amount of skew of the rollers varies the pitch of the thread and can determine the amount of thread under treatment. During this passage across the rollers the thread is subjected to a washing treatment which not only removes the acid coagulating liquor, but also residual sulphur. The yarn progresses to the ends of the rollers which are fitted with electric elements, which dry the thread. On leaving the rollers, a softening agent is applied and the thread is then twisted and wound on to a bobbin by means of a ring and traveller similar to those used in many cotton processes. The package on the bobbin is built with parallel sides and a taper top to enable the yarn to be wound off endwise at the next operation. The ring which carries the traveller is fitted into a rail which traverses in a vertical direction giving a close wind, the traversing mechanism being controlled by a hydraulic motor trip mechanism which operates an oscillating shaft actuating the movement of the rails.

The spindles are driven by means of a cotton tape from a revolving drum running along the machine, and to ensure constant speed of the spindles, and thereby constant twist, a tension pulley is applied to each tape.

Staple Fibre

As explained earlier, staple fibre is cut into suitable lengths (hence the term " staple ") to enable it to be processed in the same manner as natural fibres such as wool, cotton, etc. Often it is mixed with the natural fibres in varying proportions to achieve

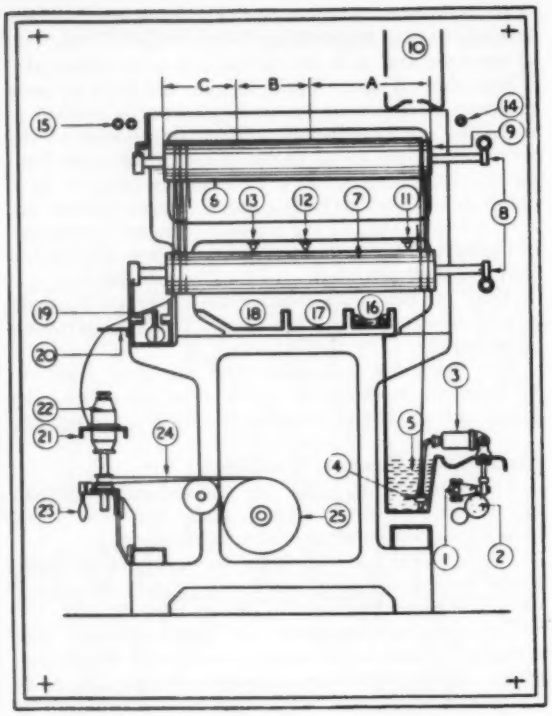


Fig. 9. Section through continuous spinning machine. 1. Viscose feed pipe; 2. Wheel pump; 3. Candle filter; 4. Spinning jet; 5. Acid bath; 6. Top thread advancing roller; 7. Bottom thread advancing roller; 8. Worm drives to rollers; 9. Step for stretch spinning; 10. Fume extraction hood; 11. Acid jet; 12. First water jet; 13. Second water jet; 14. Feed pipe for acid jet; 15. Washing water supply pipes; 16. Humidification zone; 17. Water trough for first wash; 18. Water trough for second wash; 19. Wick oiling tape; 20. Fixed lappet; 21. Ring rail; 22. Yarn package; 23. Hand brake for spindle; 24. Tape drive to spindle; 25. Driving roller.

(A) Coagulating and stretching zone; (B) Washing zone; (C) Drying zone.

Fig. 10. Full length continuous spinning machine.

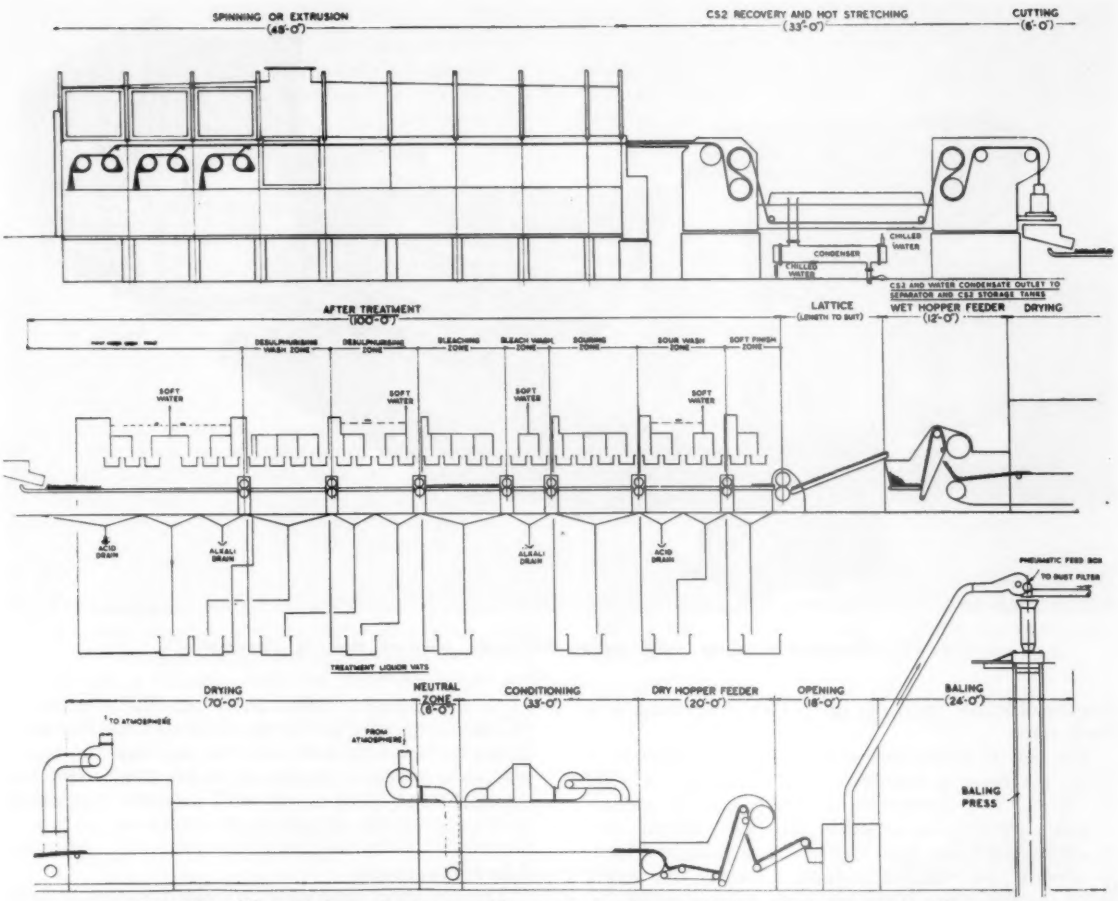


Fig. 11. Line diagram showing machine used for the production of viscose staple fibre.

different effects in the finished cloth. On the other hand, it is often processed as 100% rayon staple fibre. As the mills require the material in bale form rather than yarn package form, it will be appreciated that essentially-bulk-production is required of the staple fibre producing machinery. A basic diagram of the line of machines employed is shown in Fig. 11.

The first machine in the line is 50 feet long and is called an extrusion machine. The principle involved is that which has previously been described as "spinning". The viscose is extruded into an acid bath, and the filaments are stretched between godets and pulled to the end of the machine. The machine is double-sided and has many spinning positions. Each jet has approximately 7,000 holes depending on the final product and the "string" of filaments from each position is pulled along to marry up with the "string" from the neighbouring positions until at the end of the machine we have a heavy "rope" or tow, as it is called in the industry. This tow could have a total of 672,000 filaments or individual continuous fibres.

One of the biggest problems met with in the design of this machine was the efficient extraction of fumes from the spinning bath. Owing to the size of the machine, it was found necessary to create an extraction system which was accurately balanced to all the spinning positions and which would exhaust over 50,000 cu./ft. of air per minute.

After leaving the extrusion unit the tow is taken through a long bath of hot water at nearly boiling point, being led over large granite rollers immediately before and after the hot water bath. Thus, as these rollers can be run at different speeds, a stretch can be applied to the tow to increase its tenacity or strength. Whilst this is taking place, the residual carbon bisulphide in the tow is driven off by the hot water and the resultant CS_2 vapour is collected condensed as an economic measure. The condensed CS_2 can be re-used in the process after some purification.

The hot water tank has thus to be of an enclosed design, being fully water sealed, special arrangements being made for sealing the tow inlet and outlet ports. Illustrations of the extrusion machine and the carbon bisulphide recovery unit are both shown in Fig. 13. Upon leaving the last series of stretch rollers, the tow passes to one of two cutters. These can be varied in speed at different times in order to cut various

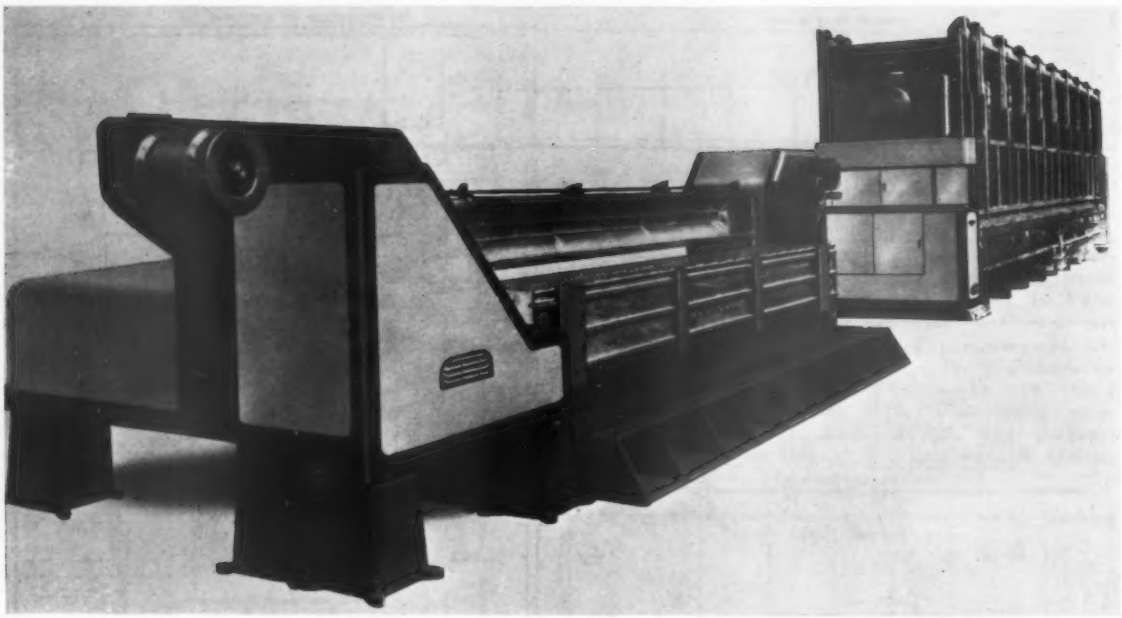


Fig. 12. Extrusion machine with carbon bisulphide recovery unit in foreground.

lengths of staple from the tow which is entering at a fixed rate.

The tow is pulled downwards into the cutter by a water jet from a source having a pressure of 100 lb./sq. in. It is interesting to note that 3,300 gallons of water per hour are used at this point alone. The jet presents the tow in as compact and straight a form as possible for efficient cutting. Lastly, the water helps the cut fibres of rayon from the cutter to the next machine.

Two cutters of the type shown in Fig. 13 are provided, in order that no stoppage is caused either by overhaul or changing of the cutter blades for regrinding every 24 hours.

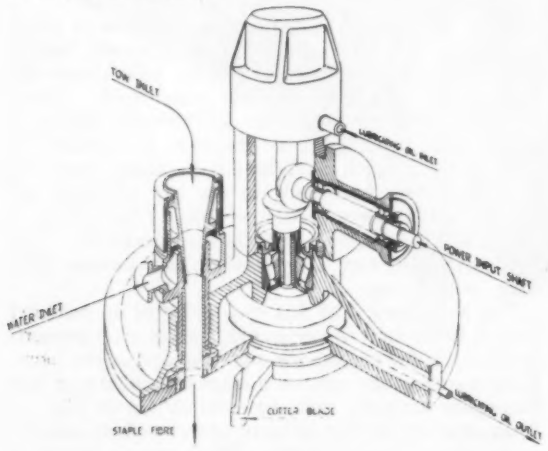


Fig. 13. Staple fibre cutter.

As the blades of the cutters may be required to cut the acidic wet tow of fibres up to 2,880,000 times in the 24 hours, it will easily be seen that the blades receive very severe treatment in operation. They are manufactured from monel with tungsten carbide inserts to resist the extreme wear imparted.

After-Treatment

The cut fibres must now be treated to remove acid, excess sulphur, and finally to bleach and lubricate them. The 96 ft. long machine shown in Fig. 14 consists of a sequence of beds onto which various treatment liquors are showered. The beds consist of a series of stainless steel tubes, some covered with ebonite for protection against corrosion. The covered shape of the tubes is in the form of a "D", with the flat surface of about 3" width uppermost. The total width of the bed is 6½ ft. and the alternate rails or tubes are connected together on to common eccentric shafts. The rayon fibres lie in a mat on the beds and are progressively moved by the alternate groups of rails coming up beneath them. That is to say, they are carried forward by the movement of one set of rails moving downward and forward, whilst the other set of rails remains stationary.

Above the beds are situated perforated tanks constructed of various materials depending on the liquor which they hold. Some are ordinary mild steel, whilst others are made from ebonite and stainless steel.

Each treatment zone is sprayed by one, two or three tanks of liquor and is separated from its adjacent zone by rubber covered squeeze rollers having a total pressure of four tons applied hydraulically to each pair. These rollers perform a dual function in saving the treatment liquor for re-circulation and in

avoiding contamination of the next treatment, with a resultant increase in the efficiency of the plant.

After the first wash, which removes the water-soluble acid and salts remaining after the spinning process, the first treatment liquor applied is usually a de-sulphurising solution which removes the residual sulphur. Secondly, a bleach of sodium hypochlorite is applied. Thirdly, a cold weak acid solution known as the " sour " decomposes any residual bleach in the fibres, and lastly, an emulsion is applied for the purpose of improving the " handle " of the material and to assist in the processing of the fibres in the spinning mill. There is, needless to say, no wash after this last process, but between all other chemical treatments.

In designing this after-treatment machine, attention had to be paid to the corrosion and handling problems of first acid, then alkali, and then weak acid again, and it will be realised that the mere sealing of bearings, framework, etc., presented many problems. Furthermore, careful choice of materials is essential, as cost as well as efficiency must be kept in mind.

Final Treatment

The actual production of the fibres now being completed, the compact mat of material must be transformed into a suitable form for presentation to the machinery in the spinning mill.

The fibres are firstly opened in the wet state by a type of machine used in the cotton spinning mill and then conveyed by a belt to a drying and conditioning machine. This passes the material forward in a state in which it contains a given amount of moisture. The conditioner of the drying machine is the controlling factor in creating this state, as it continually circulates a stream of air of controlled humidity through the fibres. After " dry " opening carried out on another cotton-type machine, the fibres are conveyed pneumatically to a baling press which compresses and binds the material into suitable bales for transit to the spinner.

This brings to an end the subject matter of this short Paper. The production of yarn from pulp has objectively been described, maybe not in detail, but with sufficient emphasis to illustrate in general the many engineering and production problems. It must also be noted that the process is a continuous mechanical process, operating 24 hours per day, seven days per week, and 50 weeks in the year, leaving the shortest possible time for maintenance; thus, reliability of the machinery involved is of paramount importance.

There must be many queries in the minds of those who read this Paper, and these can be ventilated during the discussion period.

Acknowledgments

In conclusion, thanks are due to many of the Writer's colleagues who have helped in the preparation of this Paper, and also to numerous companies who have supplied information and illustrations.

(The discussion on this Paper is reported on the following pages.)

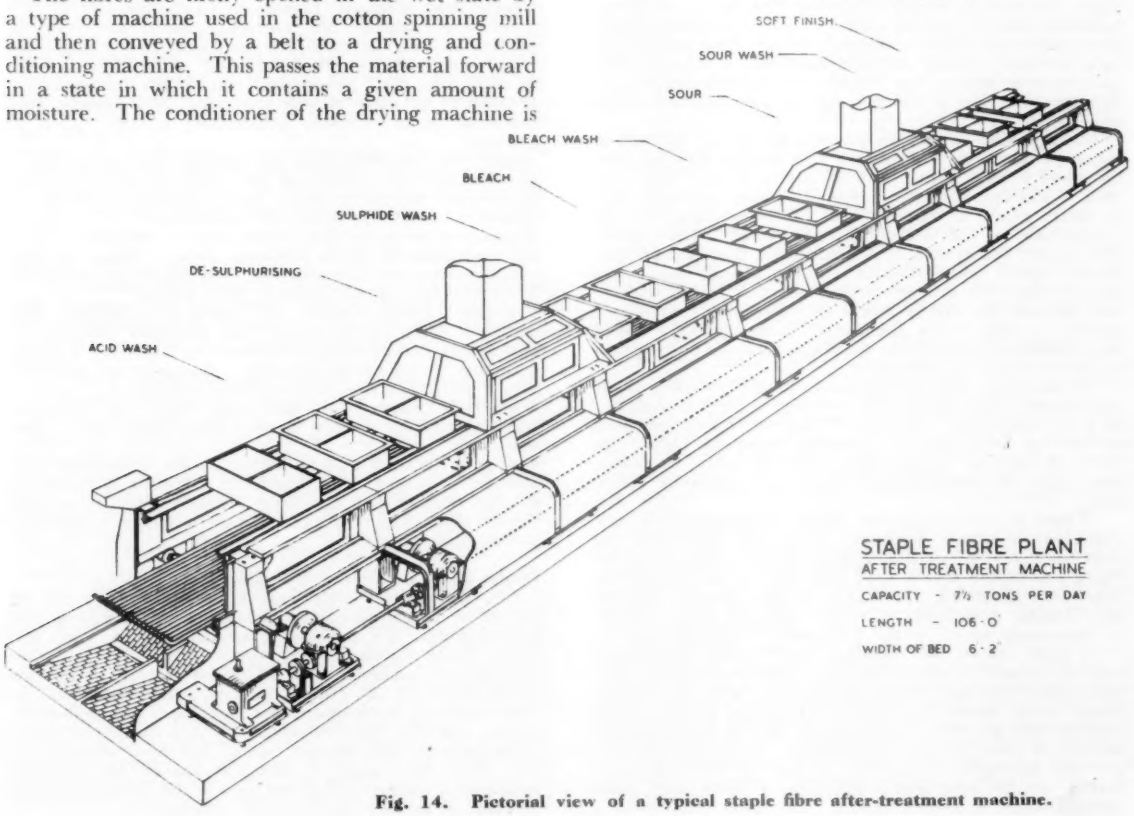


Fig. 14. Pictorial view of a typical staple fibre after-treatment machine.

THE 1954 GEORGE BRAY MEMORIAL LECTURE

REPORT OF MEETING & DISCUSSION

Chairman:

SIR WALTER PUCKEY, President of the Institution.

The Chairman, in opening the meeting, apologised on behalf of Mr. F. W. Cranmer, Chairman of the North-West Region, who was unfortunately ill and so unable to be present. On Mr. Cranmer's behalf, and on behalf of the Institution generally, he wanted to say how delighted he was that so many people had come there that evening from all Sections of the Institution in the Region and, indeed, some from well beyond the Region. This said a very great deal both for the importance of the George Bray Memorial Lecture and for the quality of the speaker.

"It is quite remarkable", said the Chairman, "that we should be holding this meeting in Lancashire, because the George Bray Memorial Lecture was in fact established in honour of an eminent Yorkshireman. On the other hand, I suppose a rose by any other name is just as sweet and in Lancashire I feel sure that you will recognise, just as the Institution does, the qualities of the man who first made it possible for the George Bray Memorial Lecture to be given at all.

"For the benefit of non-members of the Institution, I would remind you that this is the second George Bray Memorial Lecture. The first was given last year by Sir Harry Pilkington, President of the Federation of British Industries, and was on the subject of glass — what one might call a man-made fibre in another sense. This evening we have another speaker of eminence who is dealing with quite another subject, but I think both subjects would have delighted the man in whose name we have commemorated this Lecture series.

"George Bray was an eminent member of our Institution. He was a man who, both himself and through his Company, sponsored a very great deal of the work for which we stand. His own Company very generously provided after his death a sum of money which will be allocated for the maintenance of the George Bray Memorial Lecture series. The subject this evening is, I believe, one that George Bray himself would have delighted to have heard. He was a man of very wide interests, a man who felt that it was not only perhaps the narrow aspect of engineering that was of interest to him or his Company. I feel sure he would have considered the Lecture tonight to be a real contribution to the work of this Institution.

"I think the title "man-made fibres" is particularly appropriate to our speaker this evening. I use "man-made" as a substitute for "synthetic", because we rather tend to take the latter word as meaning something cheap, but there is nothing cheap about Mr. Douglas, or about the quality of these samples which are displayed before you.

"There is something very much man-made, and self-man-made, about our Lecturer. Those who have read the short summary of his background in the preprint of his Paper will realise that a man who has worked himself up from an engineering apprentice to the eminent position Mr. Douglas now holds is a quite unusual man. He is a "man-made man" in the real sense of the word.

"I must admit, Mr. Speaker, that I have not always had an unqualified admiration for textile machinery. Not very many years ago, during a very interesting but passing phase in my career, I worked in Yorkshire in the textile industry and my chief recollection of that period of service was one of noise and age of machines. These seemed to be the two descriptions attached to most of the machinery that I saw at that time; but then I knew very little about Dobson & Barlow, Ltd.! We know that it is a very great Company, having a long history. We know, too, that many revolutionary changes have been made in the textile industry, and those who have read the Paper, even those who are outside the industry, will pause in admiration at the quality, the ingenuity, the skill and the new conception of design put into the machines that Mr. Douglas will shortly describe to us.

"One thing I believe is certain — Lancashire today is supposed, in the eyes of the world, to be going through one of its periodic depressions. One does not want at this particular time to comment on the basic features of Lancashire's current depression, but with men like Mr. Douglas and the Company he represents, we may be absolutely sure that they will adapt, adopt, and ensure that in the design and production of textile machinery Lancashire will continue to lead it."

The Chairman then invited Mr. Douglas to present his Paper, which appears on pages 460/475 of this Journal.

Mr. Douglas said that he had been greatly honoured by the Institution's invitation, and was grateful to the Manchester Section for the opportunity of bringing the George Bray Memorial Lecture to Lancashire.

He would assume that everyone present had read the preprint, so that he could pin-point some of the interesting engineering problems which had had to be faced in what he might call the "pioneering" stage of the industry. For the benefit of those outside the trade, Mr. Douglas then explained some of those terms used in the Paper, as follows:-

Staple — a term indicating the average spinning length of fibres of cotton or wool and the length of fibres cut from continuous man-made fibres, for subsequent spinning on cotton, woollen, or worsted type machinery.

Rayon — a group of fibres whose basis is cellulose. There are four kinds of rayon produced today: viscose, acetate, cupramonium, and nitrocellulose. The rayons are man-made fibres, but not synthetic fibres as later defined.

Synthetic Fibres — fibres or filaments produced from polymers built up by man from chemical elements or compounds in contrast to those made by man from naturally occurring fibre-forming polymers. Examples of synthetics are: Nylon, Terylene, Orlon, Dylon, Acrilan.

Man-Made Fibres — all man-made fibres are filaments manufactured by man as distinct from those which occur naturally.

Denier — the term used to denote the size or thickness of a filament or thread. The equivalent in cotton is defined as counts. Denier was the name formerly given to a small French coin. The denier count is the weight in grammes of 9,000 metres of yarn.

Origin and Commercial Development

Mr. Douglas felt there was no need to dwell on the history of rayon, except to mention some interesting and human points. For example, it was believed that Cross and Bevan, when developing the viscose process, came to the end of their patience after trying for months to produce a thread from a viscose solution, and went out to commiserate or to try and forget their bitter disappointment. It was said that they returned two days later and before throwing away the solution, which had been standing for two days, they gave it one last chance and, behold, produced a thread! This was how it was found necessary to ripen or age the viscose before spinning.

The man whom Mr. Douglas would call the finest engineer in the trade was Topham, and the principle of his spinning box, which was known as "the Topham pot", was still accepted practice. His first effort, made from a boot polish tin, could still be seen displayed in the South Kensington Museum.

Chardonnet, who first produced man-made fibres on a commercial scale, was able to judge the strength of the effluent from his factory by walking each morning past a duck pond into which the effluent flowed. He could tell immediately, by observing whether the ducks were on the side of the pond or in the water, whether or not the effluent was neutral.

Growth of Production

With regard to the effect on future developments of the advent of the present man-made fibres, or of the new ones to come, Mr. Douglas felt sure that many in the audience would agree that the introduction of staple fibre into the cotton industry, either blended or unblended with cotton or wool or other natural fibres, had had a tremendous impact on the industry. He thought it could be accepted that in Lancashire, at any rate, there would not be as many cotton type machines working if man-made fibres had not been introduced.

He did not wish to enter into economics or politics, but he thought it must be admitted that if an indigenous supply could be obtained of a raw material to make a staple fibre that would give the qualities and characteristics of the materials at present being produced in Lancashire, it would be a very great improvement on the present position, where most of the raw material had to be imported. The various exhibits displayed in the hall showed the wide range of cloths and fabrics, distinguishable from the real thing only by an expert, which could be produced from man-made fibres.

Statistics

Referring to Fig. 1 in his Paper, which illustrated the tremendous growth in the production of rayon over the past 30 years, Mr. Douglas said he thought this would be considerably increased in the next few years. Although the bulk of the production was in America, the United Kingdom and the Continent, many other countries were now coming into the field.

New uses were being found every day, new fibres were being produced — each having its own characteristics, and either in use on its own or in combination with another could fulfil any specification as demanded by a particular application.

Process for Producing Viscose

Mr. Douglas then illustrated by means of slides and a film the methods and machinery used in the production of man-made fibres, and described the chemical and engineering problems involved. A practical demonstration was also given.

Referring to the spinning process as performed on the centrifugal principle, Mr. Douglas said that this automatic plant did not just exist in the minds of the production engineers. After investigation, an idea put forward by a Lancashire man, Mr. W. Barker, was adopted, and helped forward by the late Sir Amos Nelson. The yarn from these machines, instead of having to be processed and rewound, could be taken direct to most preparation machines for weaving, knitting, etc. This saved a good deal in labour and cost and, in fact, due to such a reduction in the handling, produced a better overall yarn.

Mr. Douglas also made particular reference to the metering pump unit. It had a body of cast iron and three hardened stainless steel plates, the middle plate carrying the metering wheels. All three plates had a honed surface, in order to obtain a flat true surface but the middle plate was especially interesting for the tolerances permissible in order to achieve a regularity, not only over months of working, but between each individual pump.

The surface thickness was honed to tolerances of ±.0005", and the centres of the two bores for the gears were internally ground to + .0001", + .0002", and the centres to ± .0001". The gear wheels, which were also hardened stainless steel, were honed to + 0" –.0002" on their width, and the outside diameter to –.0002". The bores and the pins in this pump had maximum tolerances of not more than .0005".

It was interesting to note that the method of testing this pump was to subject it to two tests: one with 100 lb. per square inch on the inlet side, with a free outlet for 100 revolutions, and the second with up to 2 lb. per square inch on the inlet side and 90 lb. on the outlet for 100 revolutions. The delivery had to be within the tolerances of + 4% and – 2½% per revolution, with a maximum difference between tests one and two not exceeding 1%.

From a production engineering viewpoint, it would be appreciated that the tooling up of this job was quite a problem, especially when it was realised that the pumps sold at less than £3 each.

Conclusion

Mr. Douglas concluded by saying that he hoped he had given, in the time available, an interesting picture of the various engineering aspects of the viscose rayon industry. He thought that in the establishment of a viscose rayon plant some unique problems had to be solved. He did not refer specifically to the European or American markets, but to the many plants erected abroad.

The producer of a rayon plant was faced, not with an order for so many machines to such a type, and so forth, but with the prospect of establishing a factory for the production of rayon where he had to start from a group of interested speculators with no experience, no technique, but only the capital— and sometimes not even that ! The engineer was expected to choose the site, which meant finding a reasonable site with an adequate water supply which would respond to treatment, a complete survey of the meteorological conditions, and adequate means of disposing of effluent should the site not be in close proximity to the sea or on a tidal river.

When all conditions had been satisfied, then it was expected that the contract, although specifying the machinery and plant involved, would be for production of a specified amount of rayon to an established standard of quality. with a specified amount of chemicals, labour, power, etc. The contract would also set out that the supplier should not only train the client's operatives, but would also maintain and control the plant until it was handed over as fulfilling the specifications laid down in the contract.

Not many engineers were faced with a prospect such as this, especially when it was remembered that this was a 24 hours per day, seven days per week process, which had to be kept going for a specified number of months in the year, with a complete break for maintenance. It should also be remembered that should a major breakdown take place, the material in the pipeline—the viscose for example —would congeal and not only become useless, but be a terrific problem to remove.

In spite of these problems, however, Mr. Douglas believed that British engineers had been the first to establish this new industry in any country, and their plants had upheld the high tradition of the British engineer.

The **Chairman**, thanking Mr. Douglas for his interesting and entertaining lecture, said it had been a fascinating description of fascinating machines. There was an exhibition which he was sure many of those present were going to look at. They had had a film show, and finally, a most interesting range of slides.

There had been one or two veiled hints of the automatic factory. Mr. Douglas had taken them towards the automatic factory as far as his particular industry was concerned, and the Chairman thought it was a notable contribution to the work of the Institution's Conference in June, on that subject.

Mr. Douglas had also given one or two hints on the possibility of Lancashire turning over more effectively to rayon or to man-made fibres as distinct from natural fibres. They were subjects which probably would invite a good deal of comment and criticism and also a very great deal of inspired help as a contribution by members of the audience.

The **Chairman** then called on **Mr. F. Heywood,** (*Director, Textile Machinery Makers Limited*) to open the discussion.

Mr. Heywood thought that the Institution was to be congratulated on choosing this particular topic. It was evident from all that Mr. Douglas had said that it was a combined operation which brought in not only the skill of the chemist and the physicist, but also that of the designer and production engineer, and many other skills. It seemed to him, in thinking of this synthetic fibre industry, that they were really, as had been said, on the verge of a new era very similar to that which emerged with the Bessemer production of steel.

Mr. Douglas had rightly said in his Paper that chemistry now produced fibres having almost any desired properties, and Mr. Heywood was certain that a period was in sight in which synthetic fibres could not only be designed to meet certain physical requirements, but would be blended in proportions to meet almost any commercial or industrial requirement. Another aspect which seemed to him to be tremendously important in this particular industry was that the chemist and the engineer, in developing these new fibres, opened up great possibilities of sales of these new fibres in export markets. It was also important that the textile engineering industry now had a great opportunity of producing in this country plant and equipment of very great complexity, involving the solution of many difficult problems. It was clear that there would be increasing opportunities of export sales of this specialised plant, not only at home, but overseas.

Mr. R. Thompson (*Research and Development Engineer, British Rayon Research, Limited*) congratulated Mr. Douglas on his very excellent Lecture and the way he had reviewed the enginering production aspects of synthetic fibre manufacture. When it was recalled that seventy years ago the textile technologists had only natural fibres to process into yarns, it made one realise the enormous task the chemist and the engineer had had in bringing about this vast growing man-made fibre industry. The American experts predicted that in 1975 no less than 41% of American textile consumption would consist of man-made yarns and fibres and, if this forecast was true, it meant that the demand for rayon would be doubled.

There was one very pleasing aspect with regard to rayon, and that was that it was not dependent, as was cotton, upon a harvest or on political situations. Consequently, there was a greater price stability with rayon staple than with natural yarns. Rayon staple at the present time was 24d. per pound—about two-thirds the price of cotton.

The statistics given by Mr. Douglas disclosed the enormous amounts of electricity, water, steam and treated water used in producing rayon yarns, and showed that there was still plenty of scope for the engineer and the chemist to improve the economy of the various processes.

In the Paper, Mr. Douglas referred to the spinning process and described the features of the spinning pump. Mr. Thompson thought it remarkable that this pump could be produced for just under £3, with the plates and wheels lapped and honed to a tolerance of .0002". Even though the engineers worked to these fine tolerances, it was astonishing to find that there would still be variations in the continuous filament of plus or minus 3%. This meant that in a batch of 100 denier yarn, extremes of 97 and 103 denier could be found. He would like to know whether these imperfections were due to the gear pump or to the spinning variation.

In the last few years, there had been a tendency to increase the numbers of fibres issued from the jet, and he would like to ask Mr. Douglas if he had found uneven coagulation due to the lower acidity in the centre of the jet. Another point that had struck Mr. Thompson was whether the maintenance fitter could get at the spinning pot motors very easily. He once, some years ago, went into a particular plant and saw some of the maintenance fitters swimming their way to the pump, but he supposed things were different now.

There was another point he would like to raise, which was more in his line of business as a textile engineer. At the present time, the rayon staple spinner was concerned with producing the best possible regular, even yarns with minimum capital equipment. Now what was known as a direct spinner had recently been brought out. That was not the spinner shown that evening—a continuous spinner. Three thousand denier tow, say, was put into a creel, and then broken up into fibrous staple material and spun into a yarn, which gave the characteristics of what was now known as a rayon staple fibre spun yarn. If they could get hold of a tow very much cheaper, this would mean that all the preliminary processes of producing yarn would be overcome and drafting material into a finished yarn would be done in one process, with the result that a yarn could be produced with a minimum amount of capital equipment.

Mr. Douglas had said that overseas cotton spinners had now equipped with modern machinery and had, to some extent, caught up with Britain. In other words, the industrial revolution in the realms of cotton spinning was behind us. Mr. Thompson believed that the next period would be a scientific revolution, which British chemists, engineers and textile technologists were very capable of carrying out in this country.

Mr. Douglas, in reply, said that it was always difficult to name the causes of unevenness of yarn. In cotton spinning they had been chasing that elusive factor for years, and had not found it yet, but there were one or two factors in rayon which had to be taken into consideration.

One was that in the solution put to the spinning machine there was approximately 7% cellulose. There could be quite a variation which the pump could not deal with. There were also the variations in the pump, and he thought it would be agreed that as the years went on, more and more perfection in pump design and manufacture would be achieved.

With regard to holes in jets, and whether the penetration was obtained with fewer holes or with a larger number of small holes, they had carried out a large number of experiments, even putting a pathway in the centre of the holes, but he did not think that anything had been proved. So far they had found that the penetration did not vary tremendously.

Referring to the direct spinning frame, that was a long way off perfection. In cutting up a dry fibre, there was created a burr on the yarn which they had still not found any way of overcoming, and one beauty of staple fibre was the fact that by putting it through cotton machinery, they got blending, which helped to even out irregularities.

Mr. R. H. S. Turner (*Director and Works Manager, Metropolitan-Vickers Electrical Company, Limited*) said he would like to ask Mr. Douglas a very simple question with regard to the importation of products required to manufacture rayon. It had been suggested that it might be the saving of the textile industry to change over from cotton, which had to be imported, to the manufacture of rayon, but as he understood it, the timber required was not grown in this country. It was imported, in the form of cellulose, and in addition there was a large number of chemicals used in the manufacture of rayon, of which he judged sulphur to be fundamentally important. Sulphur was imported into the country and was in short supply in the world. Perhaps Mr. Douglas would say what he considered the future of rayon to be in relation to imports in the foreseeable future.

Mr. Douglas pointed out that in his remarks about finding an indigenous substance from which to produce staple fibre, he had been trying to imply that this was not the end. Rayon had been produced from sugar cane, from seaweed, from bamboo and other cellulose plant life. He was not a scientist, but surely something could be grown in the United Kingdom from which rayon could be produced.

With regard to sulphur, it was true that it was used in quantity in many industries and had to be imported. But he was optimistic enough to think that this problem, like many others, would eventually be overcome.

Mr. J. O. Knowles (*Chairman and Joint Managing Director, Brookhirst Switchgear, Limited*) asked if there was any published information available regarding the electrical control and the instrument mechanism of the plant required.

Mr. Douglas was not aware of any special publications. Most of the electrical equipment used was standard, by which he meant that the turbo-generators, the compressors,

the humidification control, the temperature control and so on, were all standard products.

Mr. J. D. W. Taylor (*Director and Works Manager, William Ayrton and Company, Limited*) enquired if Mr. Douglas could describe how the holes were drilled in the jets. Also, at what speed was the viscose extruded into the sulphuric acid bath? How was it possible for all the threads together to come out into the tow at the end? Did the rayon have to age when it had been wound on the cake? And was there a limit to the time it could be kept on these cakes?

Another point Mr. Taylor wished to refer to was the use of spun rayon in the braiding of electrical cables. It was sized and polished. Was there any particular mixture which could be used, which was better than the size mixture used for cotton, i.e., the water starches and waxes? Was there any particular ingredient which could be added to advantage? Finally, could Mr. Douglas give a simple formula for finding the number of threads per inch in the rayon, knowing the denier?

Mr. Douglas, in reply, said that he had never seen the drilling of holes in jets. It was done by the jewellers, and he thought they used two methods: a flat drill, or the method used in drilling very fine diamond drawing dies, that was, tapping.

The speed of extrusion at the jet was dependent on what was being spun, but it would normally be something like 70 to 90 metres a minute.

With regard to the age of rayon cakes, the cakes in this section were acidic, and therefore the acid would attack the cellulose unless it was removed fairly quickly. Normally, they would be put into a damping chamber if they had to be kept longer than a certain number of hours, but it was preferable to wash them quickly free of acid, and then they could be kept as long as desired.

Mr. Douglas regretted that he could not answer the question regarding the sizing of electric cable—it was right outside the process with which he was concerned.

Referring to the denier, this was the weight in grammes of 9,000 metres of yarn. This had nothing to do with the number of threads in that denier. All that could be done was to find out the number of filaments in the thread, and then work out the denier for each filament. It was a question of the type of cloth that was going to be produced: the more filaments, the softer the cloth.

Mr. J. D. Shackleton (*Assistant Works Manager, Kirklees, Limited*) asked if Mr. Douglas would give a little more information regarding the discharge cycle of the steeping press? He believed that this type of press was used a good number of years ago, and discarded in many rayon plants because of difficulties—the time saved did not offset the disadvantages of leaks and troubles at this point. He would be interested to know what the time cycle was for automatic discharge from the steeping press, as unloading by hand was not a long job.

Mr. Douglas could not give the time cycle off-hand, but if he had to say which was the quicker method he would say, definitely, unloading by hand, for the simple reason that it was usual for a press to unload through the end, and the ram had to traverse the full length. Unloading by hand meant that it was only necessary to go up to the final pressing position, then return and reload. But it was a messy job and the operative had to be considered.

The **Chairman,** in closing the meeting, commented that anything he might say must be regarded as something of an anti-climax. He had been rather disappointed that the wider issues hinted at by the speaker, and which the Chairman believed were within the scope of the production engineer, had not been discussed more fully.

One important point mentioned by Mr. Douglas was the problem of the automatic factory. It was easy in some ways, to show a diagram which depicted the elements of an inter-connected group of mechanism or equipment. On the other hand, the problem of maintenance was barely touched upon. The problem of capital investment in relation to output had hardly been discussed at all, and neither had the problem of redeployment of the people who would not work at the productive machines, but who would probably be required in design offices, maintenance departments and similar places. All these things were of great interest but they had hardly been brought out that evening.

Mr. Turner had referred to the problem of raw materials. Mr. Douglas hoped, and so did Mr. Turner, for a considerable expansion of rayon production in the United Kingdom. A doubling of production had been mentioned, taking some American figures as a basis. The Chairman wondered what grounds there were for assuming that? He wondered how many years it was likely to take? He believed that the capital investment necessary to increase to that particular figure was a very large one indeed, and one was therefore led to the conclusion that it might compete with many other forms of capital for many other forms of expansion in this country.

Mr. Turner had mentioned one other important point, the supply of raw material. It was one thing to say that cotton came from abroad, but so far there was no answer to the supply of alternatives from home sources. These were the sort of problems which must obviously be left to another occasion.

There was one last point, on which he would like to say a few words, and that was the position of Lancashire today.

Lancashire, as he had said in his introductory remarks, was going through one of her periodic depressions. He believed that she was, in her textile industry, suffering from the fact that she was a pioneer of the industrial revolution, and those who pioneered found that eternal vigilance was needed to keep ahead. Fortunately for Lancashire, she had many firms in the textile and engineering fields, such as the one with which the speaker that evening was connected, and one could hardly imagine them falling behind in the international race.

One could not help feeling, however, that the long term decline of the textile industry as a whole was a problem not yet fully appreciated. Some sections of the textile industry were dying; but new skills, new trades, new opportunities for employment, were coming up to take the place—and more than the place—of the dying industries. In the long run Lancashire might not necessarily be a textile country but she might well achieve a new reputation by adapting her qualities to new materials and technologies in the same manner as they had seen demonstated so well that evening.

Mr. G. Ronald Pryor (*Chairman of Council*), proposing a vote of thanks to Mr. Douglas, said that the present occasion had proved a memorable evening in the history of the Institution. He felt sure that the audience would agree that the Paper—which he had read with the greatest interest—had been enhanced by the very vivacious way in which Mr. Douglas had amplified the high spots.

Mr. Pryor thought that they had seen that evening the justification of two things; in particular, of the wisdom of the donors of the George Bray Memorial in requesting that the Lectures be drawn from other than the metal-working industries and, more generally, the fact that the Council of the Institution had decided on the policy of "Broadening the Base". He thought Mr. Douglas had done the Institution a great service in that direction, and nobody would leave the hall with any doubt as to the function of a production engineer in one industry, at any rate, away from the metal-working industries.

It might be of interest to Mr. Douglas to know that at the Midland Regional Dinner of the Institution, on Friday night, when the chief guest was Sir Edward Boyle, who had just been promoted to the Cabinet as Economic Adviser to the Treasury, Sir Edward, in proposing the health of the Institution, had urged the Institution to extend its activities outside the metal-working industries.

Finally, Mr. Pryor expressed appreciation of the splendid way and great good humour with which Mr. Douglas has handled the discussion.

Mr. Douglas, thanking Mr. Pryor, said he would like to take the opportunity of thanking all the individuals who had helped him in the preparation of his Paper. His staff had worked magnificently and he wanted to say how grateful he was to them. If their efforts had been appreciated by the Institution, they had been well repaid for what they had done.

The proceedings then terminated.

THE PRINCIPAL OFFICERS

1955/56

The President

Sir Leonard Lord, K.B.E., *Chairman and Managing Director of The British Motor Corporation.*

Sir Leonard, who was educated at Bablake School, Coventry, served his apprenticeship with the Engineering Department of Courtauld's Ltd., Coventry. After spending some time with various companies in Coventry, London and Peterborough, he joined the Wolseley Works purchased by Mr. W. R. Morris (now Viscount Nuffield). He was appointed Managing Director of Morris Motors, Ltd., in 1932, and in this capacity he controlled Morris Motors, Ltd., Cowley; Wolseley Motors, Birmingham; the M.G. Car Company; and other companies.

Sir Leonard retired from Morris Motors in 1936 at the age of 40 and travelled extensively abroad. He was Manager of Lord Nuffield's £2,000,000 Trust Fund to aid Special Areas, and administered the Trust from 1937/38. He was a member of the Committee of Management and Works Director of The Austin Motor Company, Ltd. from 1938, and also Government Controller of Boulton Paul, Ltd. from 1940.

He became Deputy Chairman and Joint Managing Director of The Austin Motor Company in 1941, on the death of Lord Austin. He was also responsible for the production of airframes and aero-engines at Austin Shadow factories during the War.

In November, 1945, following the retirement of Mr. E. L. Payton, he became Chairman of the Board of Directors and Managing Director of the Austin Motor Co. Ltd.

He became Deputy Chairman and Managing Director of The British Motor Corporation when the Austin/Nuffield merger was announced in 1951, and became Chairman and Managing Director on the retirement of Lord Nuffield in 1952.

In addition he is Chairman and Managing Director of the Austin Motor Co., and its subsidiaries, and Chairman and Managing Director of Morris Motors Ltd., and its subsidiaries.

The Chairman of Council

Mr. G. Ronald Pryor, *Chairman and Managing Director, Edward Pryor & Son, Ltd., Sheffield.*

Mr. Pryor became Chairman of Council in 1954 and has been elected to serve a further term of office.

Educated at Wellington College, Salop, he was apprenticed in 1919 to the family firm of Edward Pryor & Son. Ltd., which was founded in 1843.

He is a Past President of the Sheffield Section of the Institution of Production Engineers and a Past Chairman of the Sheffield Section of the Institute of Industrial Administration, of which he is a Fellow. He has served on the Council of The Sheffield Chamber of Commerce since 1951, and was subsequently appointed Vice-Chairman of the Education Committee of the Chamber. In 1953, he was appointed a member of the Commerce Committee of the Yorkshire Council for Further Education.

Mr. Pryor takes a keen interest in production research, and has served on the Council of the Production Engineering Research Association of Great Britain since 1950, and on the Executive Committee of this body since 1951.

Among his many interests are beagling, sailing, ornithology and photography. He also enjoys travelling and has visited most European countries, Canada and the United States.

The Vice-Chairman of Council

Mr. H. G. Gregory, *Manager (Northern Factories), Fairey Aviation Company, Ltd., Stockport.*

Mr. Gregory has been Vice-Chairman of Council since 1954, and has been elected to serve a further term of office. He is a Past President of the Manchester Section of the Institution, and a Past Member of the Membership, Standards and Hazleton Memorial Library Committees.

The Principal Officers take office on 1st July, 1955.

Mr. E. W. Barrell, Member, has relinquished his position as Chief Production Engineer of Bonnington Castings Ltd., Edinburgh, and has taken an appointment as Works Manager of Churchill-Redman Limited, Scotwood Division, Newcastle-on-Tyne.

Mr. H. D. S. Burgess, Member, has been appointed to the Boards of Commer Cars Limited, and Karrier Motors Limited and has assumed the responsibilities of Works Manager. Mr. Burgess served his apprenticeship with Vauxhall Motors Limited and subsequently became Chief Jig and Tool Draughtsman. In 1939 he was appointed Works Manager of the Coventry Gauge and Tool Company and later became General Works Manager of the Wickman Machine Tool Factory. He joined the Rootes Group in 1944 and was appointed Planning Manager of Humber Limited, where he remained until last year when he became Rootes Group Production Engineer.

Mr. H. D. S. Burgess

Mr. Burgess, who has been a member of the Institution for 25 years, is a Past President of the Coventry Section and has served on the Institution's Membership Committee. He has also served on various British Standards Committees representing the Institution and also The Society of Motor Manufacturers and Traders.

Mr. H. H. Evans, Member, a Production Executive of Cincinnati Milling Machines Limited, Birmingham, has been elected a Director of Hordern, Mason & Edwards Limited, Birmingham.

Mr. W. J. Ford, Member, has been promoted from Manager of the Peterborough Branch, to Manager of the Welsh Branch of Holman Bros. Limited. Mr. Ford has relinquished the Chairmanship of the Norwich Section, and now serves on the South Wales and Monmouthshire Section Committee.

Mr. Bernard W. Gould, Member, who has been associated with the Department of Industrial Administration in the College of Technology, Birmingham, since it was founded in 1947, has taken over increased responsibilities as Senior Lecturer for the Factory Organisation Aspects of Industrial Administration.

Mr. Gould, who was trained at McCorquodales, served for many years with B.T.H. Company Limited, and with Klaxon Limited; he is well-known among production engineers and managers in the Midlands as Honorary Secretary of the Midland Region of the Institution. At the College of Technology in Birmingham he has been responsible for initiating and directing the new six-weeks' full-time programme in "The Organisation and Control of Production", which has recently been established in the Department of Industrial Administration.

Mr. I. G. Hopkinson, Member, Works Manager of Hopkinsons Limited, has now been appointed to the Board. He is a Past President of the Halifax Section.

Mr. K. J. Hume, Member, has been appointed Chief Education Officer to the Dowty Group, and will take up his duties in August of this year. The appointment follows on the recent decision of the Group to extend considerably its educational activities, which includes provision for training aprentices.

Mr. K. J. Hume

Mr. Hume, who has been Head of the National College of Horology since 1951, received his early training at the National Physical Laboratory and, at the same time, studied for a science degree at The Polytechnic, Regent Street. He later joined The de Havilland Aircraft Company as Metrology Superintendent, remaining with the Company during the Second World War. For a period after the War he was engaged on development work with Messrs. Hilger & Watts Ltd., until he took up his present appointment.

Mr. Hume is Chairman of the Institution's Papers Committee, and serves on the Editorial and Standards Committees. He is also a member of several B.S.I. technical committees and a founder member and Chairman of the Engineering Metrology Association.

Mr. J. O. Knowles, Member, Chairman and Joint Managing Director of Brookhirst Switchgear Limited, has been appointed to the Board of Metal Industries Limited. Mr. Knowles is a Past President of the Liverpool Section.

Sir Henry Spurrier, Member, has been appointed to the Board of the District Bank. Sir Henry is Managing Director of Leyland Motors, a director of Albion Motors and is also on the Boards of a number of other companies.

Mr. J. T. Rymer

Mr. J. T. Rymer, Member, Managing Director of Sentinel (Shrewsbury) Ltd., has been appointed Chairman of the Company. Mr. Rymer has also been appointed to the Board of Metal Industries Limited.

This photograph, taken at the Annual Dinner of the Halifax Section held on 25th March, 1955, shows *(left to right)* Sir Walter Puckey, President of the Institution ; Mrs. J. E. Hill, (wife of the Regional Chairman) ; Mr. F. J. Everest, Chairman of the Section ; and the chief guest, Dr. W. A. Tuplin, Professor of Applied Mechanics at Sheffield University.

Mr. George Wright, Member, General Manager of The Bristol Aeroplane Company Limited's Engine Division since January, 1952, is being released from his appointment with The Bristol Aeroplane Company Limited on 31st August, at the request of The Asquith Machine Tool Corporation Limited, in order to accept a position as an Executive Director of The Asquith Machine Tool Corporation Limited and certain of its subsidiary companies.

Mr. George Wright

Mr. Wright is a Past President of the Western Section of the Institution.

Mr. A. Barton, Associate Member, has taken up an appointment as Methods Engineer with Hoffmanns (Gloucester) Limited, Stonehouse, Gloucester.

Mr. T. H. Fraser, Associate Member, has left the United Kingdom to take up the position of Production Engineer in his Company's new Australian factory, Allied Ironfounders (Pty.) Ltd., Melbourne, Australia.

Mr. C. B. Griffiths, Associate Member, has been appointed Works Manager of the Incandescent Heat Co. Ltd., the parent company of the Incandescent group whose headquarters are at Smethwick, Staffs. Mr. Griffiths joined the organisation in 1946 after serving in the Forces for six years as a Captain in the R.E.M.E. Prior to which he was on the engineering staff of Richard Thomas and Baldwin Limited. He is well-known within the Institution as an active member of the Materials Handling Sub-Committee. He has also been Publicity Officer of the Kidderminster and District local Committee of the British Productivity Council since its formation.

Mr. A. K. Haskins, Associate Member, has now taken up an appointment as Lecturer in Production Engineering at the Borough Polytechnic, London.

Mr. S. G. Hayden, Associate Member, has taken up an appointment as Planning Engineer with Wade Engineering Ltd., Brighton.

Mr. T. L. Isaacs, Associate Member, has been appointed Chief Production Engineer, No. 3 Factory, Glacier Metal Company, Kilmarnock.

Mr. F. Kelly, Associate Member, is now employed by The Pioneer Oilsealing & Moulding Co. Ltd., Colne, Lancashire, as Development Engineer.

Mr. C. Lacey, Associate Member, has relinquished his position with Dalton & Gallon Limited, Bradford, and is now Planning Engineer with Auto-Components Ltd., Thorne, Doncaster.

Mr. J. Renouprez, Associate Member, has been appointed Works Manager of John Mountford & Co. Ltd., Clayton Forge, Manchester.

Mr. E. Scott, Associate Member, has relinquished his appointment as Works Manager of Singer Motors Limited and has taken up a position with The Rover Company, as Works Superintendent at their Axle Works in Birmingham.

Mr. J. L. Taylor, Associate Member, has recently taken office as Chief Technical Designer to Allied Ironfounders Ltd. (Northern Group).

Mr. D. Critchley, Graduate, has taken up an appointment as Production Engineer with The Forgrove Machinery Co. Ltd., Leeds.

Mr. R. W. Griffin, Graduate, has taken up an appointment as Designer in the Advance Truck Engineering Department of Ford Motor Company, Dearborn, Michigan.

Mr. G. H. Newton, Graduate, has recently been appointed Work Study Engineer, for the Meter, Relay and Instrument Division of the English Electric Co. Ltd., Stafford, responsible for the Product Development and Work Measurement sections.

Mr. W. G. Slater, Graduate, has relinquished his position as Assistant Works Engineer at Joseph Sankey & Sons Limited, and has taken up an appointment as Works Engineer at British Rolling Mills Ltd., Tipton.

Mr. G. Smith, Graduate, has relinquished his position as General Manager, Greenbrook Engineering Co. Ltd., Padiham, and has taken up an appointment with Hindle Son & Co. Ltd., Blackburn.

Mr. K. J. Thompson, Graduate, has been transferred from G.E.C., Coventry, to the new G.E.C. Factory in Portsmouth to take charge of the Production Engineers Office.

Mr. H. Wall, Graduate, has recently taken up an appointment with Lec Refrigeration Limited, Bognor Regis, as a Planning Engineer.

OBITUARY

The Institution has learned with deep regret of the death of **Mr. L. R. Chandler,** Member, and **Mr. T. McGlashan,** Member. Mr. Chandler, who was Principal of the Ipswich College of Technology, was also a Member of the Institution of Mechanical Engineers. He was a Corresponding member of the Papers Committee. Mr. McGlashan was a member of the Lincoln Section Committee from its formation in 1943, until his retirement in 1952, and was Chairman of the Section for the 1949/50 Session.

Lt.-Col. L. F. Urwick, O.B.E., M.C., M.A.

At a recent luncheon in the Roosevelt Hotel, New York, the Wallace Clark International Management Medal was awarded to a member of the Institution, Lt.-Col. L. F. Urwick. The presentation was made by Professor Schell, President of the Council for International Progress in Management and is for a "distinguished contribution to Scientific Management in this field".

The award is administered by the Council for International Progress in Management and the first presentation was made in 1949. Colonel Urwick is the first Briton to receive the award and was also the first Briton to receive the Gold Medal of the International Committee of Scientific Management in 1951.

Visitor from Overseas

Professor Mansergh Shaw, Associate Member, Head of the Department of Mechanical Engineering of the University of Queensland will be visiting the United Kingdom at the end of the year. During his stay in Britain he intends to study industrial developments, particularly in his own field of manufacture and metrology, and will also visit new University laboratories to gain ideas for the design of the new laboratories which are shortly to be erected at his own University.

HAZLETON MEMORIAL LIBRARY

Owing to pressure on space, book reviews and additions to the Library are held over for the time being.

RESEARCH PUBLICATIONS

A number of copies of the following Research publications are still available to members, at the prices stated :

Report on Surface Finish, by Dr. G. Schlesinger	15/6
Machine Tool Research and Management	10/6
Practical Drilling Tests	21/-

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge", Melton Mowbray, Leics.

The Council of the Institution

1955/56

President

Sir Leonard Lord, K.B.E.

Chairman of Council

G. R. Pryor

Vice-Chairman of Council

H. G. Gregory

Immediate Past Chairman of Council

H. Burke

Past Presidents

Major-General K. C. Appleyard, C.B.E. Sir George Bailey, C.B.E. Sir Alfred Herbert, K.B.E. Norman Rowbotham, C.B.E.
The Rt. Hon. Viscount Nuffield, G.B.E. Sir Walter Puckey J. D. Scaife Dr. H. Schofield, C.B.E.
The Rt. Hon. Lord Sempill, A.F.C. Sir Cecil Weir, K.C.M.G., K.B.E., D.L., M.C.

Presidents of Councils outside the United Kingdom

AUSTRALIAN COUNCIL—J. N. Kirby
SOUTH AFRICAN COUNCIL—W. G. Gillespie

Chairmen of Regional Committees

East & West Ridings
F. T. Nurrish, M.B.E.
Eastern
E. N. Farrar
Midlands
H. Burke
North Midlands
A. S. Johnstone
Northern
T. McCulloch
North Western
F. W. Cranmer
Northern Ireland
G. H. Moore
Scotland
M. C. Timbury
South Eastern
R. E. Leakey
Southern
T. H. Christy
South Western
C. C. Cornford
Wales
W. H. Folds

Additional Representatives on Council

East & West Ridings
J. E. Hill
Midlands
S. J. Harley
North Western
E. G. Eaton
South Eastern
R. Telford

Chairmen of Standing Committees

K. J. Hume B. H. Dyson R. E. Mills C. L. Old S. A. J. Parsons M. Seaman
The Rt. Hon. Lord Sempill, A.F.C.

Elected Members

A. J. Aiers H. W. Bowen, O.B.E. R. S. Brown R. M. Buckle A. G. Clark R. S. Clark Wm. Core. B. H. Dyson
E. P. Edwards F. J. Everest R. S. Hind B. G. L. Jackman R. Kirchner Prof. T. U. Matthew B. E. Stokes
A. L. Stuchbery C. Timms R. H. S. Turner

Co-opted Member

T. Fraser, C.B.E.

Chairmen of Sections outside the United Kingdom where Councils are not established

Bombay
J. V. Patel
Canada
C. J. Luby
Calcutta
B. F. Goodchild
New Zealand
E. Paton

Overseas Councils

AUSTRALIA

President

J. N. Kirby

Chairman
C. Pullen

Vice-Chairman
J. O. Ogden

Elected Members

C. J. Clark R. W. Deutsher S. Downie N. Eaton N. Esserman W. M. B. Fowler W. Gwinnett W. L. Hemer
E. Herbert J. H. Law J. Steer J. E. Strick H. G. Sutton A. Welsh L. W. Worthington

A certain number of new Council Elections have not yet been completed. Where this applies the office bearers for 1954/55 *are shown.*

UNITED KINGDOM

Birmingham	B. W. Gould, Dept. of Industrial Administration, College of Technology, Suffolk Street, Birmingham.
Cornwall	F. G. Hawke, 17 Church Road, Pool, Redruth, Cornwall.
Coventry	W. G. Key, 128 Green Lane, Coventry.
Derby	P. Warburton, 27 Albemarle Road, Chaddesden, Derby.
Doncaster	W. H. Edwards-Smith, "Hindscarth", Melton Road, Sprotbrough, Nr. Doncaster.
Dundee	J. Nicolson Low, Technical College, Bell Street, Angus, Scotland.
Eastern Counties	A. B. Brook, Davey, Paxman & Co. Ltd., Britannia Works, Colchester.
Edinburgh	W. Sinclair, Brown Bros. & Co. Ltd., Rosebank Ironworks, Edinburgh, 7.
Glasgow	W. H. Marley, G. & J. Weir Ltd., Coltness Foundries, Newmains, Lanarks.
Gloucester & District ...	C. L. Mawhood, 132 Brooklyn Gardens, Cheltenham.
Halifax	Miss N. E. Bottom, Hopkinsons Ltd., Huddersfield.
Leicester & District	D. G. Swinfield, 65 St. Saviour's Road, Leicester.
Lincoln	H. Wright, 101 Longdales Road, Lincoln.
Liverpool	R. T. Spencer, 44 Kremlin Drive, Stoneycroft, Liverpool 13.
London	R. J. C. Whitaker, The Glacier Metal Co. Ltd., Ealing Road, Alperton, Middlesex.
Luton	J. F. W. Galyer, Engineering Dept., Luton & South Beds. College of Further Education, Park Square, Luton, Beds.
Manchester	G. R. Parker, 101 Green Lane, Garden Suburb, Oldham, Lancashire.
North Eastern	A. C. Foskew, 35 Oakwood Avenue, Low Fell, Gateshead, 9.
Northern Ireland	W. G. Wyman, 'Hopecroft', Glenavy, Co. Antrim.
Norwich	F. H. S. Heidenstam, 33 Cecil Road, Norwich.
Nottingham	C. N. T. Manfull, Chellaston House, Thurgarton Street, Nottingham.
Oxford	M. J. Inston, 53 Rymers Lane, Cowley, Oxford.
Peterborough	E. G. Perrett, 13 Francis Gardens, Peterborough, Northants.
Preston	R. Thompson, 71 Willows Lane, Accrington, Lancs.
Reading	R. W. H. Mark, 'The Beeches', 41 Reading Road, Woodley, Berks.
Rochester & District	W. G. Clements, 11 Charing Road, Gillingham, Kent.
Sheffield	T. F. Newton, 20 Exley Avenue, Sheffield, 6.
Shrewsbury	W. M. Buchan, Llanberis, Mytton Oak Road, Shrewsbury.
Southern	J. W. Taylor, 44 Deacon Road, Bitterne, Southampton.
South Essex	D. S. Redhead, Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex.
South Wales & Mon. ...	J. Bolwell, Messrs. Creed & Co. Ltd., Treforest Industrial Estate, Pontypridd, Glam.
Stoke-on-Trent	R. Rowley, North Staffordshire Technical College, Stoke-on-Trent.
Tees-Side	T. A. Horsley, 24 Clarence Road, Nunthorpe, Nr. Middlesbrough.
Western	A. Eustace, 19 Ferndale Road, Northville, Bristol, 7.
West Wales	H. P. Sanderson, I.C.I. Ltd., Metals Division, Waunarlwydd, Nr. Swansea.
Wolverhampton	R. J. Sury, Widdicombe House, 2 Buttons Farm Road, Penn, Wolverhampton.
Worcester	R. Wheeler, Old Farm House, Parish Hill, Bournheath, Nr. Bromsgrove, Worcester.
Yorkshire	J. L. Townend, 26 Moor Allerton Drive, Street Lane, Leeds, 17.

CORRESPONDING MEMBER IN MIDDLE EAST

J. Merkine, 45 Arlozoroff Street, Ramat-Gan, Israel.

CORRESPONDING MEMBER IN EGYPT

A. F. Abdo, 29 Taleb Street, Terha Bolackia, Shouba, Cairo.

CORRESPONDING MEMBER IN IRAQ

W. G. Rooke, Production Engineer, Iraqi State Railways, Shalchiyah, Bagdad, Iraq.

CORRESPONDING MEMBER IN BRITISH WEST AFRICA

H. P. Halfter, Gold Coast Rlys. & Harbour Admin., P.O. Box 202, Takoradi, Gold Coast, B.W.A.

GRADUATE SECTION HONORARY SECRETARIES

Birmingham	W. E. Hipkiss, 17 Briery Road, Halesowen, Birmingham.
Coventry	A. S. Hopkins, 39 Oaks Road, Kenilworth, Warwickshire.
Halifax	G. Harrison, 5 Myrtle Grove, Quarmby, Huddersfield.
Liverpool	G. L. Smith, 17 Withers Street, Liverpool, 7.
London	J. G. Hyland, 91 Hereford Road, Bayswater, London, W.2.
Luton	M. J. Hemmett, 20 King Georges Avenue, Watford, Herts.
Manchester	R. C. Yarnell, 1 Demesne Road, Whalley Range, Manchester, 16.
North Eastern	R. F. Loebl, 32 Deneside Avenue, Low Fell, Gateshead-on-Tyne, 9.
Sheffield	G. Shaw, Horseshoe Cottage, Holmesfield Road, Holmesfield, Nr. Sheffield.
Western	K. D. Marwaha, Central Y.M.C.A., Colston Street, Bristol 1.
Wolverhampton	W. L. Pace, "Linden" 10 Ezekiel Lane, Short Heath, Willenhall, Staffordshire.
Yorkshire	(Acting) J. L. Townend, 26 Moor Allerton Drive, Street Lane, Leeds 17.

LOUGHBOROUGH COLLEGE STUDENT SECTION

S. K. Maini, Dept. of Industrial Engineering, College of Technology, Loughborough, Leics.

REGIONAL HONORARY SECRETARIES

East & West Ridings ...	Miss N. E. Bottom	**Northern Ireland**	W. G. Wyman
Eastern	L. A. Childs	**Scotland**	W. H. Marley
Midlands	B. W. Gould	**South Eastern**	R. Hutcheson
North Midlands	D. G. Swinfield	**Southern**	J. W. Taylor
Northern	C. C. Hodson	**South Western**	A. Eustace
North Western	G. R. Parker	**Wales**	J. Bolwell

Secretary of the Institution

W. F. S. Woodford

SECTION CHAIRMEN

C. J. Clark	*Adelaide*	F. Baker	*North Eastern*
T. W. Elkington	*Birmingham*	G. H. Moore	*Northern Ireland*
J. V. Patel	*Bombay*	V. Crowther	*Norwich*
B. F. Goodchild	*Calcutta*	L. Shenton	*Nottingham*
C. J. Luby	*Canada*	L. P. Coombes	*Oxford*
H. M. Sawyer	*Cornwall*	F. H. Adams	*Peterborough*
W. G. Rootes	*Coventry*	E. G. Paton	*Preston*
A. Short	*Derby*	T. H. Christy	*Reading*
G. R. Whitehead	*Doncaster*	W. T. Cottingham	*Rochester*
A. Williamson	*Dundee*	E. Levesley	*Sheffield*
F. T. Dyer	*Eastern Counties*	B. G. Williams	*Shrewsbury*
A. Betts Brown	*Edinburgh*	R. Telford	*South Essex*
M. C. Timbury	*Glasgow*	W. H. Folds	*South Wales*
T. E. Love	*Gloucester*	F. T. West	*Southern*
F. J. Everest	*Halifax*	H. Porter	*Stoke-on-Trent*
J. C. Routledge	*Leicester*	J. O. Ogden	*Sydney*
R. S. Hind	*Lincoln*	R. H. Archer	*Tees-Side*
J. H. Winskill	*Liverpool*	W. H. Bowman	*West Wales*
R. E. Leakey	*London*	C. C. Cornford	*Western*
R. M. Buckle	*Luton*	C. L. Old	*Wolverhampton*
H. Spencer Smith	*Manchester*	R. H. Higgs	*Worcester*
C. P. Pullen	*Melbourne*	D. H. Turnbull	*Yorkshire*
E. Paton	*New Zealand*		

GRADUATE SECTION CHAIRMAN

A. C. Turner	*Birmingham Graduate*	J. P. Speakman	*Manchester Graduate*
L. B. Rutter	*Coventry Graduate*	G. D. Robson	*North Eastern Graduate*
M. Alderdyce	*Halifax Graduate*	E. Willcox	*Sheffield Graduate*
A. J. Vine	*Liverpool Graduate*	R. Powell	*Western Graduate*
F. H. Johns	*London Graduate*	E. Springthorpe	*Wolverhampton Graduate*
R. St. John Aylieff	*Luton Graduate*		

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Sydney (New South Wales) ...	A. Welsh, Room 802, 16 Barrack Street, Sydney, Australia.

CANADA

Canada	P. M. Wood, 31 Conway Avenue, Toronto, 10. Ontario.

INDIA

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Calcutta	C. K. Haldar, T.D.E. Weapons, Gun and Shell Factory, Cossipore, Calcutta 2.

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New Zealand	G. Stedman, 3 Harrison Avenue, Belmont, Takapuna, Auckland, N.2, New Zealand.

SOUTH AFRICA

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. . . where accuracy and economic production are vital factors the **Austin Motor Co. Ltd.** employ Newall crankpin and cylindrical grinders in their production lines for crankshafts used in the internationally famous range of Austin Cars and Commercial vehicles.

An extremely robust machine, the Newall Model 'LA' automatic cylindrical grinder illustrated above is a versatile unit adaptable for the production of a wide range of components.

Size range: Centre Heights 10″ or 16″

Distance between centres—24″ 36″ 48″ 60″ 72″ 84″

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NEWALL GROUP SALES LIMITED

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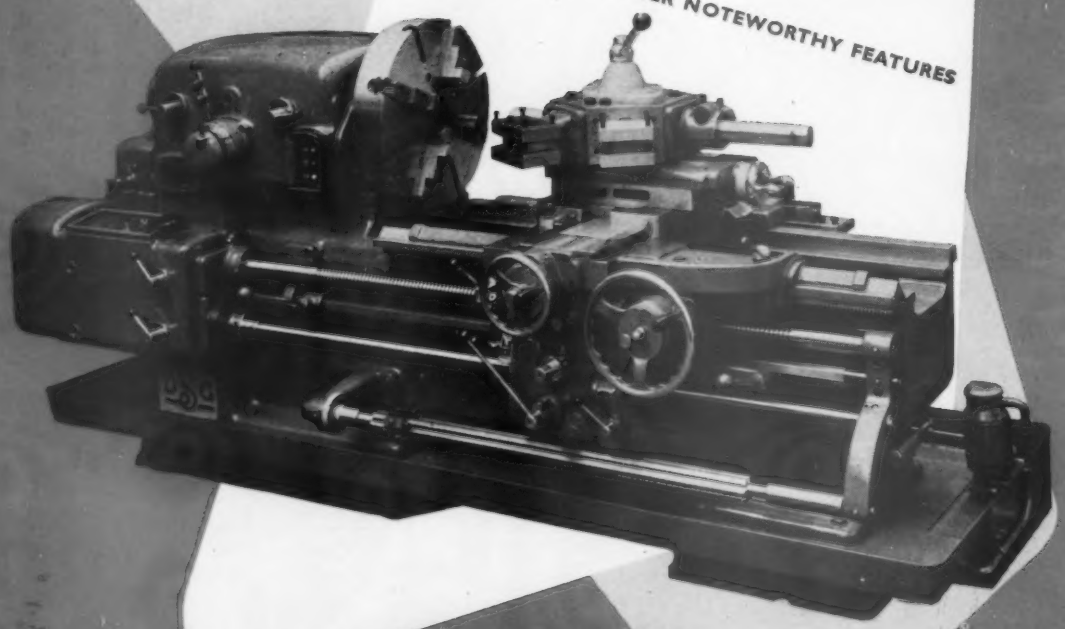
ACHIEVEMENT

IN LATHE MANUFACTURE

NUMBER 2

the 24" swing SURFACING AND BORING LATHE

- TOTALLY ENCLOSED GEARBOX
- TWIN PLUNGER TURRET LOCATION
- RAPID CENTRE POSITIONING WITH RETRACTABLE STOP
- TOOL HOLDER INTER-CHANGEABLE WITH BRITISH TURRET LATHES
- AND MANY OTHER NOTEWORTHY FEATURES



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KEIGHLEY LIMITED ENGLAND

We manufacture... 13" – 30" SWING ENGINE LATHES · SURFACING & BORING LATHES · TOOLROOM LATHES

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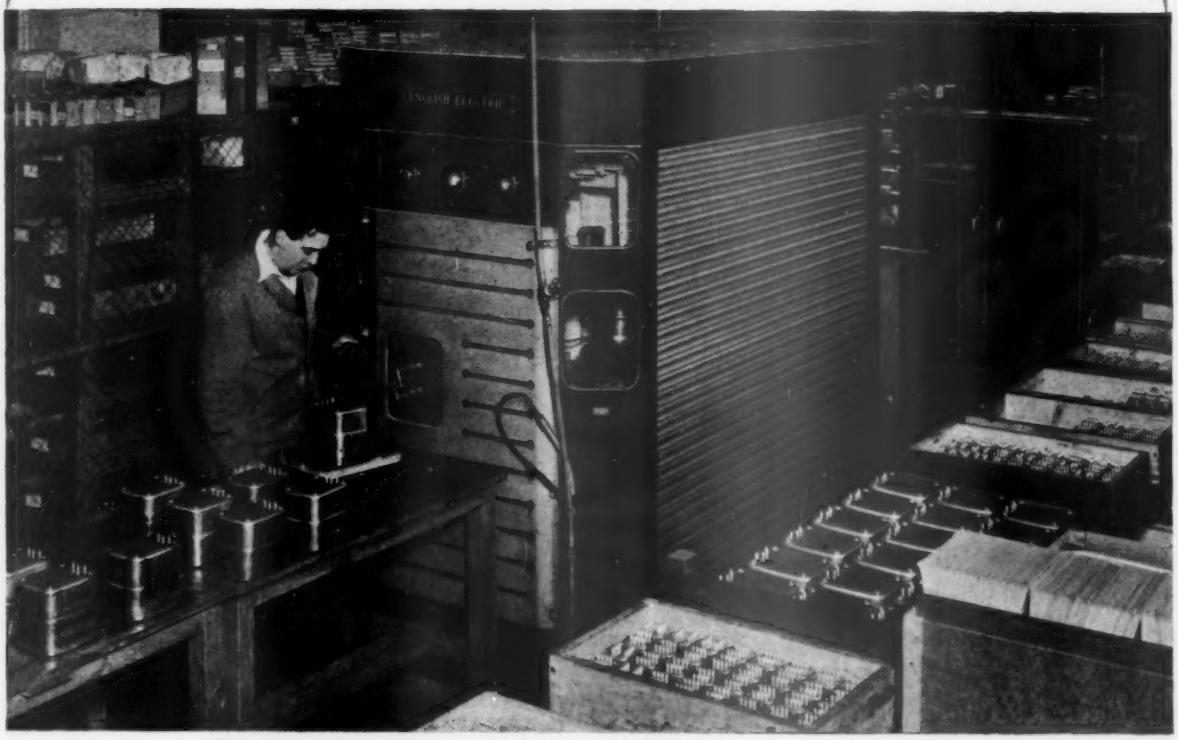
Instantaneous heat



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Instruments for the automatic controlling, recording, indicating and telemetering of physical values, as applied to industrial processes.

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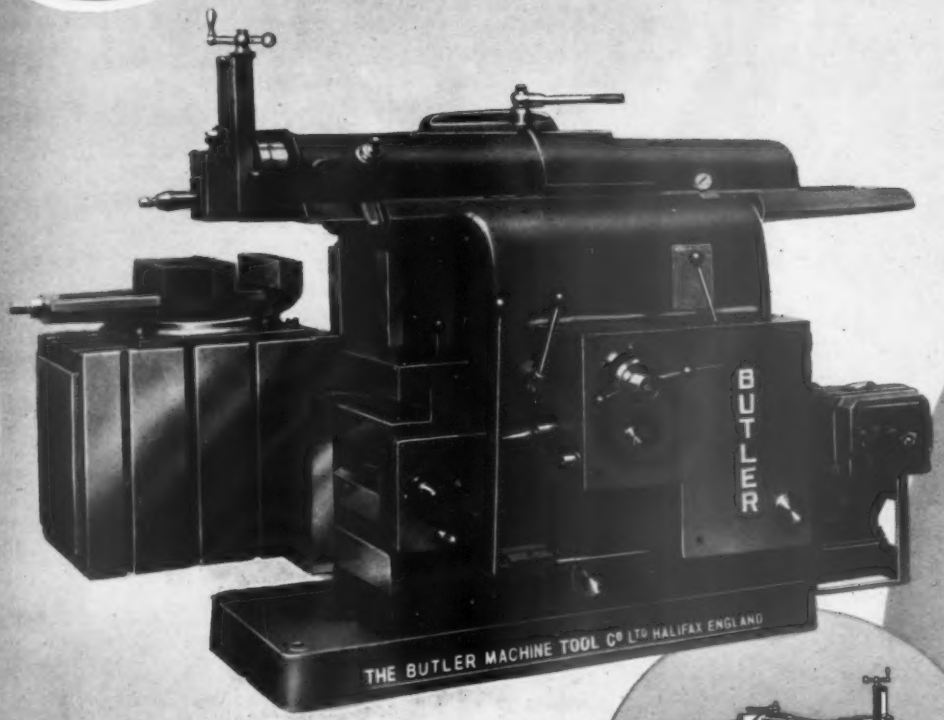

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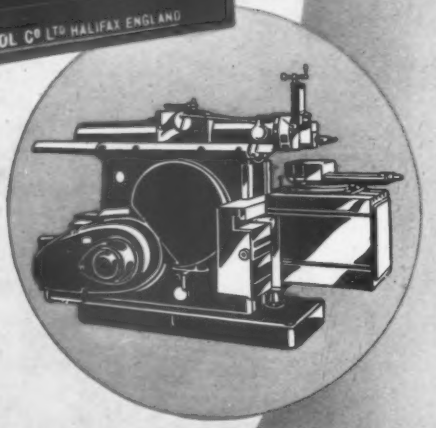

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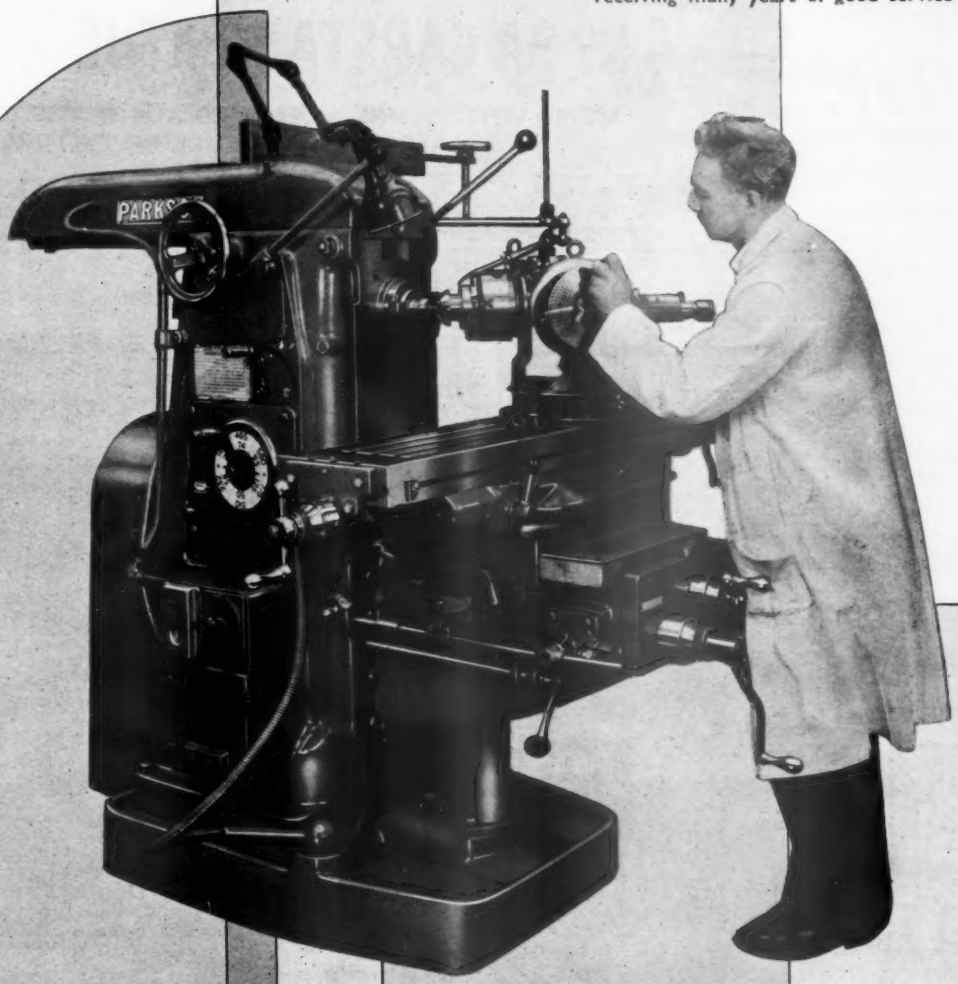

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P361B

For Maximum Production

Ward Nº 3A CAPSTAN LATHE

FITTED WITH 1¼" HAND-OPERATED AUTOMATIC CHUCK WITH LARGE COLLET CHUCKING FIXTURE

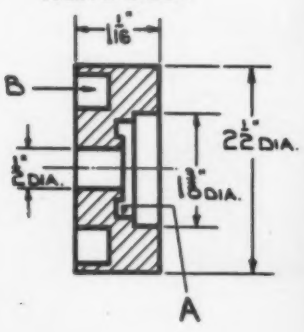
DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
Chuck on 2½" dia.	—	—	—	—	—
Face End	—	Rear	1155	750	Hand
Start Drill	1	—	668	250	Hand
Drill	2	—	668	90	Hand
Bore ½" dia., recess A and 1⅜" dia.	3	—	668	240	Hand
Finish Bore A and 1⅜" dia. and Chamfer	4	—	668/slow	240	Hand
Reverse Component in Collet	—	—	—	—	—
Face End	—	Front	1155	750	Hand
Trepan Bore B and Chamfer	5	—	376	225	Hand
Ream ½" dia.	6	—	376	50	Hand
Remove	—	—	—	—	—

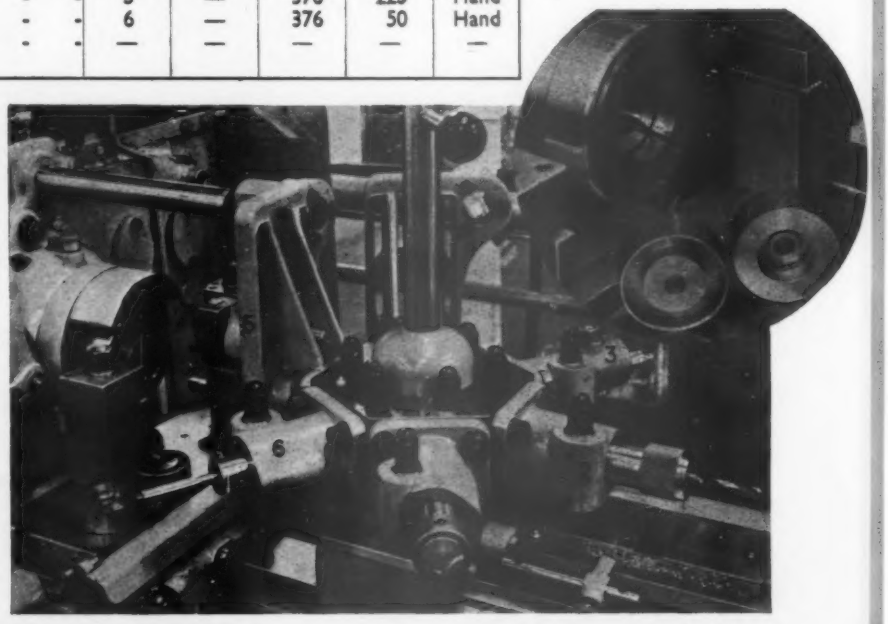
Free Cutting Mild Steel, En. 1
(Blanks 2½" dia. × 1¼" thick)

High Speed Steel Cutting Tools

Floor to Floor Time: 3 minutes

VALVE BODY





Capacity: 1¾ in. dia. hole through spindle. 13⅛ in. dia. swing over bed.
Spindle: Mounted in ball and roller bearings.
Powerful friction clutches running in oil transmit power through ground gears.

OUR COMPLETE RANGE INCLUDES CAPSTAN AND TURRET LATHES WITH CAPACITIES UP TO 35 in. SWING OVER BED AND 8½ in. DIA. HOLE THROUGH SPINDLE.

Full details on request

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SELLY OAK TELEPHONE — BIRMINGHAM 29 SELLY OAK 1131

W614

A week's work in a day!

MAXAM engineers were called in early in the development of this machine; now it automatically drills, forms and faces five holes—the largest 1½" deep—in 28 seconds. Previous methods had taken over 3 minutes, so that production is now 500% up and the machine does more than a week's work in a day!

In this case the MAXAM system comprised five hydro-pneumatic feed units, fitted with air-motors and coupled to the necessary air pilot and electric valves providing sequence, interlock and isolation control.

Your problem may be in refrigerator assembly, furniture glueing, the placing of bottles in their crates or in any other field. Whatever it is, you really should consider the possibilities of MAXAM automatic operation. May we send you a descriptive leaflet or a catalogue?

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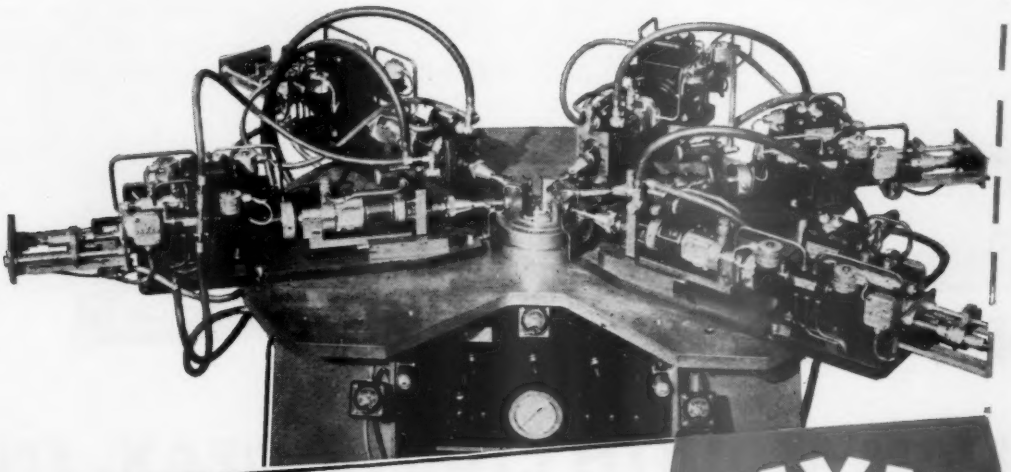
4, Broad Street Place, London, E.C.2. Works: Carn Brea, Cornwall.



and for your job too—

MAXAM PNEUMATIC SYSTEM

TAS/CX 563

Tell us how you want it

ASQUITH Unit Heads, suitably placed around a workpiece, enable a number of multiple drilling operations to be carried out simultaneously. Changes in design can also be catered for without recourse to a complete new machine. Constructed on the most modern lines they uphold the ASQUITH tradition for efficiency and economy.

ASQUITH

UNIT HEADS

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MAXICUT steps ahead again . . !

AVAILABLE IN CAPACITIES UP TO 11 ins. by 78 ins.

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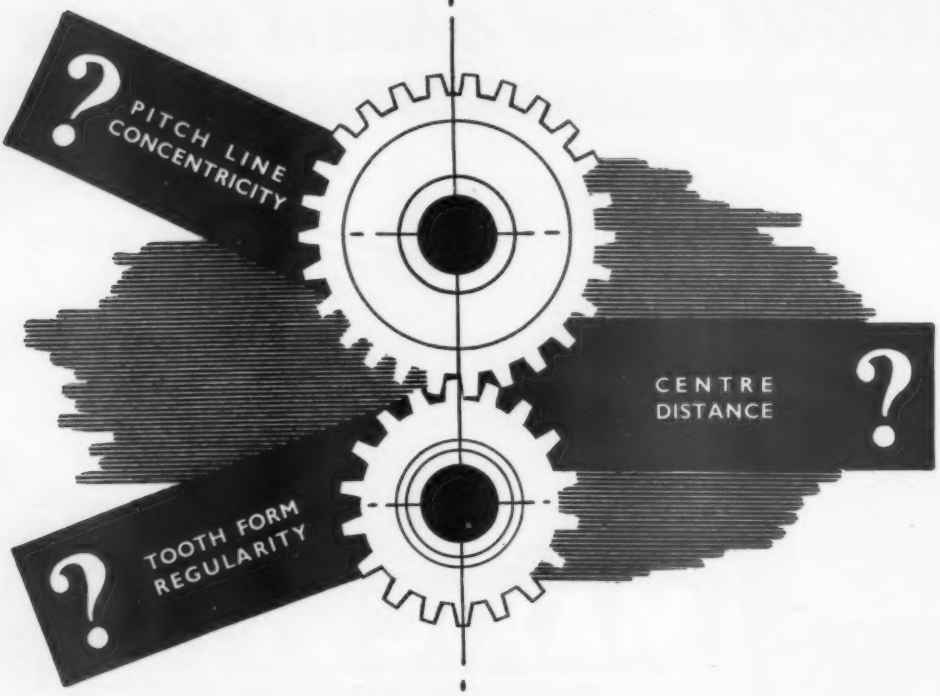
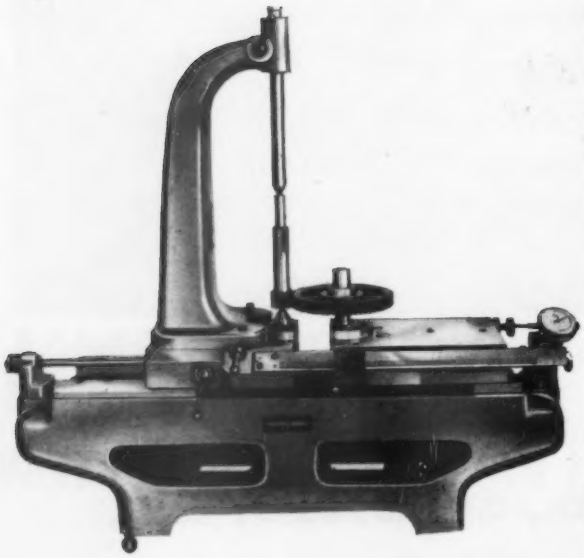


Wadtool gives the answers!



The WADTOOL provides the quickest and easiest method of checking gears in quantity. It should be made available in any department responsible for the inspection of spur, bevel and worm gears and worm wheels.

Wadtool
PRODUCTION
GEAR TESTERS

Maximum centres—10 ins.
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CONTROLLED MATERIALS PLACEMENT

- *saves time and floor space*
- *eliminates duplicate handling*

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With Rack Conveyor Systems you bring order out of chaos, help speed assembly or machining and save operator's time. Because of the usable vertical space provided, the Rack method affords as much as six times the working capacity for every square foot of floor space it occupies!

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6 of the 18 Rack Units Available

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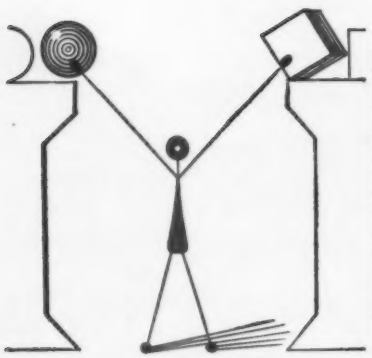
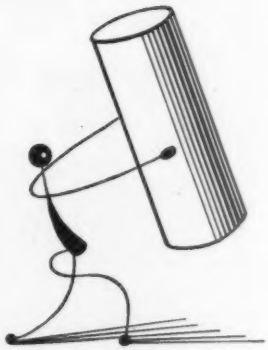
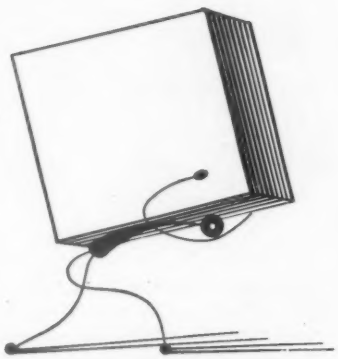
IS THE NAME FOR MACHINES THAT



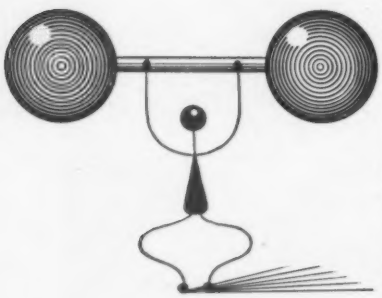
...reach...



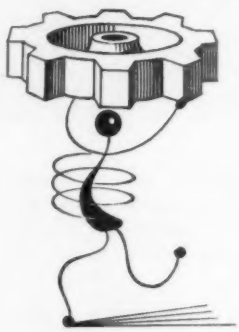
...grasp...



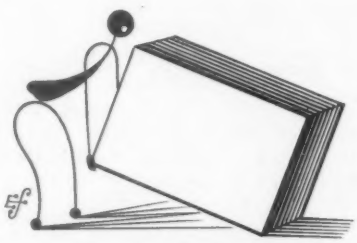
...carry...



...lift...



...turn...



...tilt...

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Hymatic Automation

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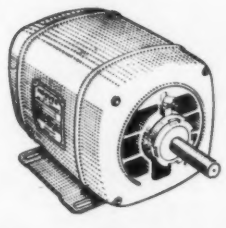

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Thread Rolls reground at a fraction of the original cost.

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The **Harrison**

15" SWING LATHE

for maximum return on your money

15 3/4" SWING OVER BED
12 SPINDLE SPEEDS
SPINDLE BORED TO PASS 2" OR 3"
36" TO 79" BETWEEN CENTRES

● **Whether you need increased plant for Toolroom or general production work a Harrison lathe is a sound investment.**

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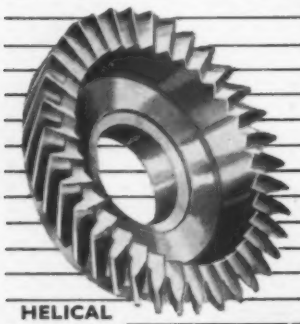
Precision with Economy

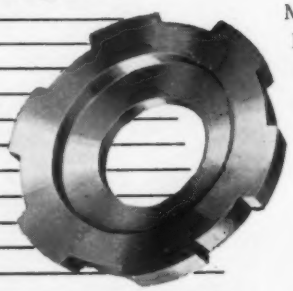
SPUR DISC TYPE

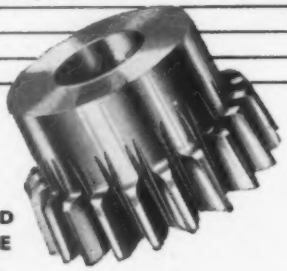
CHAIN SPROCKET TYPE

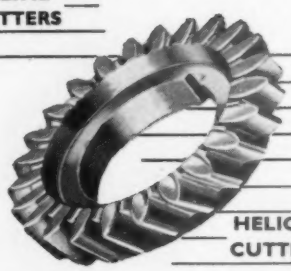
There's a Sykes Precision Cutter for every gear production job. Standard types are available from stock and a specialised service provides for speedy design and production of special purpose tools. You can rely on them for accuracy and service, for they are the result of many years continuous development by an Organisation specialising in the design of gear cutting Machines and Tools. Each blank is separately forged from High Speed Steel of special analysis. Heat treatment is under close control and the scientifically proportioned cross-section provides maximum support to the cutting edge, ensuring accuracy and economy throughout a long productive life.

PRE-SHAVING TOOLS · PRE-GRINDING TOOLS
MODIFIED PROFILE TOOLS
HIGH PRECISION FINE PITCH CUTTERS
HOBS · SHAVING TOOLS


HELICAL DISC TYPE


SPLINE CUTTERS


EXTENDED BOSS TYPE


HELICAL CUTTERS

HUB TYPE

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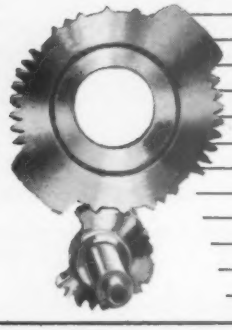
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on these lines

higher production means shorter delivery

We are not content to fill our order book for Spenstead equipment and rest complacently on a sound economic outlook, we believe that every client—old and new—has a right to early delivery. To this end, we are constantly adapting, constantly laying down production schedules on a broader, grander scale. Whether it is in the manufacture of Pneumatic Shot Blast Rooms and Cabinets; "Airless" Multi-Table, Rotary Barrel, Flat Bed Table; or Overhead Monorail Blast Cleaning Plant, this policy is applied to the full.

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PNEUMATIC & AIRLESS SHOT BLAST CLEANING PLANT

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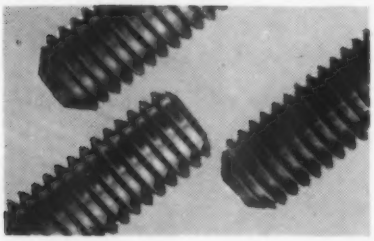
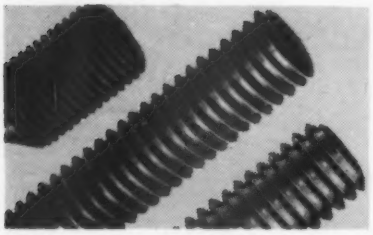
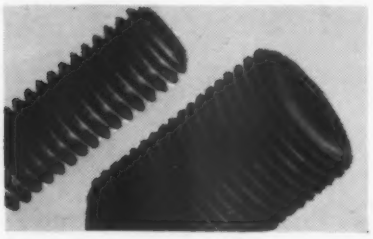
Why Unbrako?







To speed production? Look for easy thread start, the hex socket for speedy, sure drive.

For staying power? Unbrako closer tolerances mean a better fit, and their tremendous toughness allows the screws to be pulled up tighter, to stay put longer without locking. Unbrako vibration tests prove this.

For dependability? The reputation of the best equipped specialist screw organisation in Europe stands behind every single Unbrako production, so they've got to be good. They are obtainable all over the world.

UNBRAKO SCREWS COST LESS THAN TROUBLE

UNBRAKO

UNBRAKO SOCKET SCREW CO., LTD., COVENTRY

JUST THE DRILL

Just as we regret the decline of the horse in rural life, so we welcome the introduction of the "little horses" to industry. The contribution they are making to increased productivity needs no repetition here. As the demand for Desoutter tools increases so does the demand for our castings which are widely used in their design. But increased orders from existing customers—satisfying as they are to receive—have brought us new problems. Until a major development programme now well advanced is completed we may find it difficult to accept orders from new customers in spite of the fact that our output has risen by over 50% to 150,000,000 zinc and aluminium alloy pressure die castings each year.

30 YEARS' ANGLO-AMERICAN DIE-CASTING EXPERIENCE

WOLVERHAMPTON DIE-CASTING
AFFILIATED WITH
PRECISION CASTINGS CO. INC. (U.S.A.)

CERTIFIED ZINC ALLOY ZAMCA DIE CASTERS

THE WOLVERHAMPTON DIE-CASTING COMPANY LIMITED

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Pellegrini

GEAR HOBBING MACHINES

For cutting splined shafts, spur, helical and worm gears.

MODEL	D.500	D.690
Maximum work diameter	20½"	27"
Maximum work diameter with outer support removed	26"	40"
Maximum pitch	4 D.P.	2½ D.P
Minimum number of teeth	6	6
Approximate weight	2 tons	4 tons

SPECIAL FEATURES

- Equally efficient for small batch or large-scale production of accurate components.
- Automatic stops for sizing purposes.
- Tangential feed to cross slide.
- Independent rotation of hob spindle and work table for special types of work if required.

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Selson MACHINE TOOLS

The Selson Machine Tool Co. Ltd

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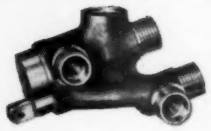
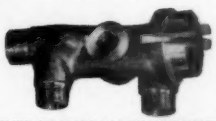
HIGH-PRODUCTION MULTI-OPERATION AUTOMATIC

FORKED ADAPTOR



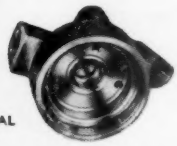
66 SECS



FORKED ADAPTOR COMPLETELY MACHINED IN TWO PASSES THROUGH THE EPPINGER ESA2. TOTAL TIME 66 SECONDS.

END COVER

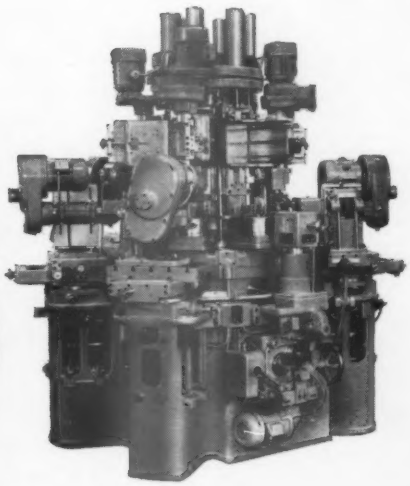
108 SECS



END COVER COMPLETELY MACHINED IN THREE PASSES. TOTAL TIME 108 SECONDS.

72 SECS

4-WAY COUPLING, COMPLETELY MACHINED IN TWO PASSES. TOTAL TIME 72 SECONDS.



MODEL ESA2

From the Hahn and Kolb Range

Cut working and setting times with the Eppinger Multi-Operation Automatic. Various operations — drilling, boring, counter boring, counter sinking, reaming, milling, mortising, threading and tapping — can be carried out at one setting by a vertical and horizontal work unit at each of five stations; loading and unloading taking place at the sixth. Write for illustrated leaflet 2/EP giving full details.

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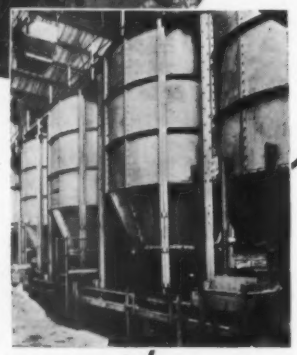
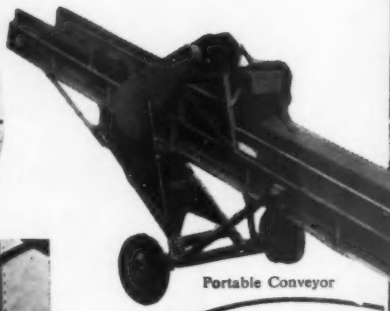
Complete Telpher Installations



Sand Storage Hoppers



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Something worth knowing

Paterson Hughes Mechanical Handling Systems are used in almost every industry in the world.

Portable Sack Elevator

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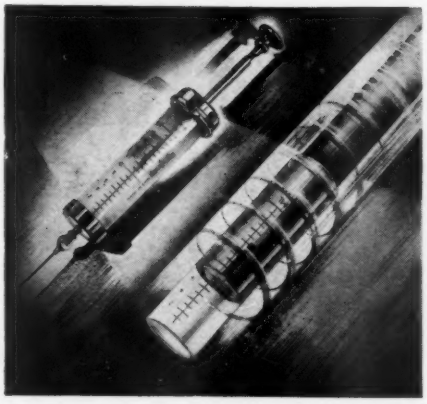
MECHANICAL HANDLING ENGINEERS AND CRANE MAKERS

the medical diamond



The accurate dispensing of liquids with the aid of a hypodermic depends on the accuracy and finish of the bore in the glass tube and its mating plunger. Diamond Powder is employed to obtain the desired finish and accuracy in the glass bore. In this as in many other operations, the very close grading of Dia-dust ensures high production rates with minimum scrap.

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Lion-branded is lion hearted

Strong as a lion, in fact, in head and handle. Bedford hammers are forged from durable Sheffield Steel in the Bedford factory and the shafts are made from selected ash or hickory—supplied according to preference. All types are sold with or without handles.

if it's a good hammer it's a

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JOHN BEDFORD AND SONS LTD LION WORKS SHEFFIELD

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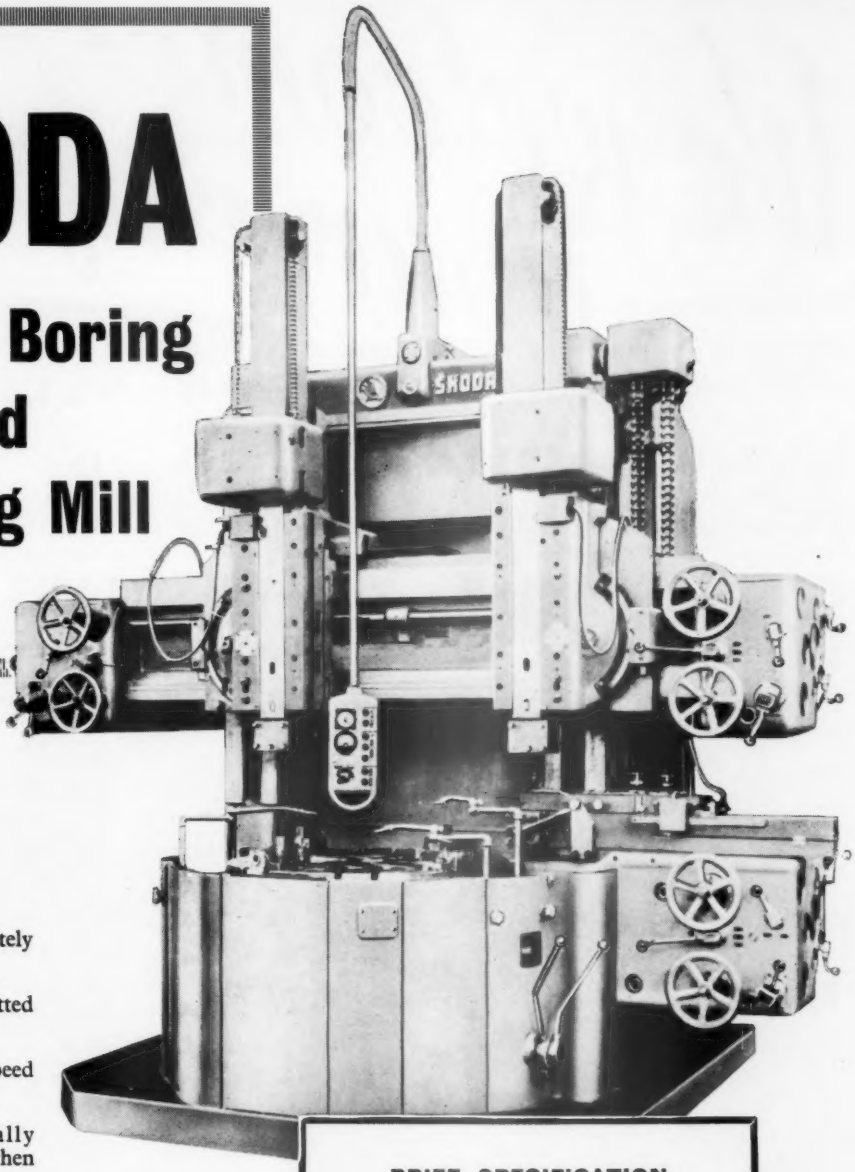
SKODA

Vertical Boring and Turning Mill



MODEL SK12 ILLUSTRATED

High table speeds, infinitely variable.

Anti-friction bearings fitted to spindle.

Drive through variable-speed commutator motor.

Cross-rail automatically clamped and unclamped when raising or lowering.

BRIEF SPECIFICATION

Maximum swing with side head	49 in.
Maximum swing without side head	53 in.
Maximum distance between table and rail head toolholder	39 in.
Table diameter	46½ in.
Infinitely variable speed from	3.55-150 r.p.m.
Variable speed motor output	27 kW.
Weight of machine	15,600 kg.

EARLY DELIVERY

Selson MACHINE TOOLS

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The Selson Machine Tool Co. Ltd

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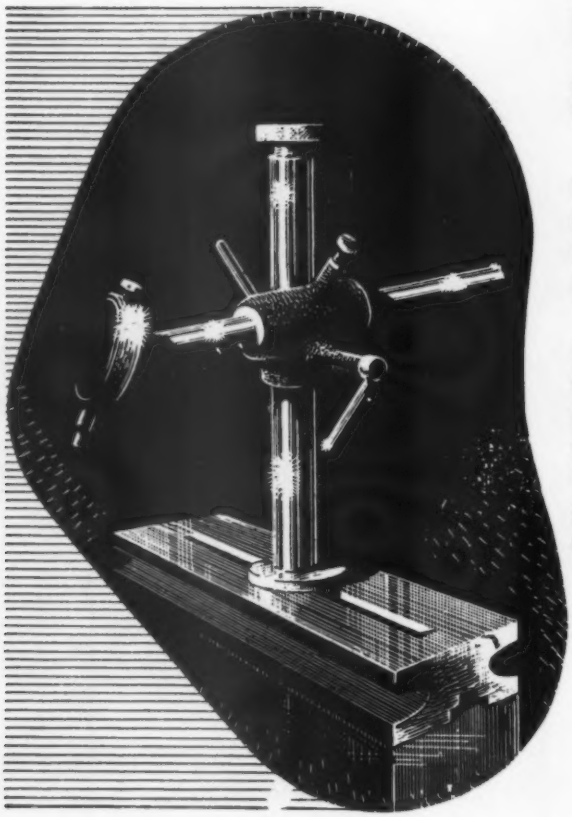
We welcome your enquiries

FOR ALL KINDS OF

JIGS · FIXTURES & GAUGES



PRESS TOOLS · MOULDS AND SPECIAL PURPOSE MACHINES

Our commitments are heavy but we welcome an opportunity to study your requirements for inclusion in our production programme where possible.

Up-to-date shops specially laid out and equipped for making, on a production basis, every type of precision ground gauges; limit snap, form, calliper, taper and special purpose gauge, as well as jigs and fixtures of all kinds, press tools moulds and special purpose machines. Highest class workmanship and accuracy guaranteed.

Guaranteed
Precision
Accuracy

G.P.A.

G.P.A. TOOLS & GAUGES LIMITED

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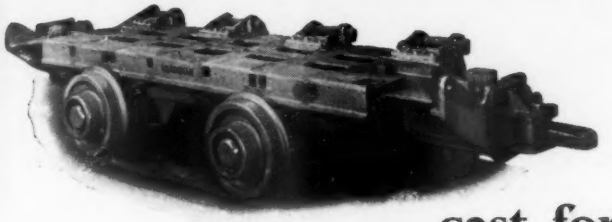
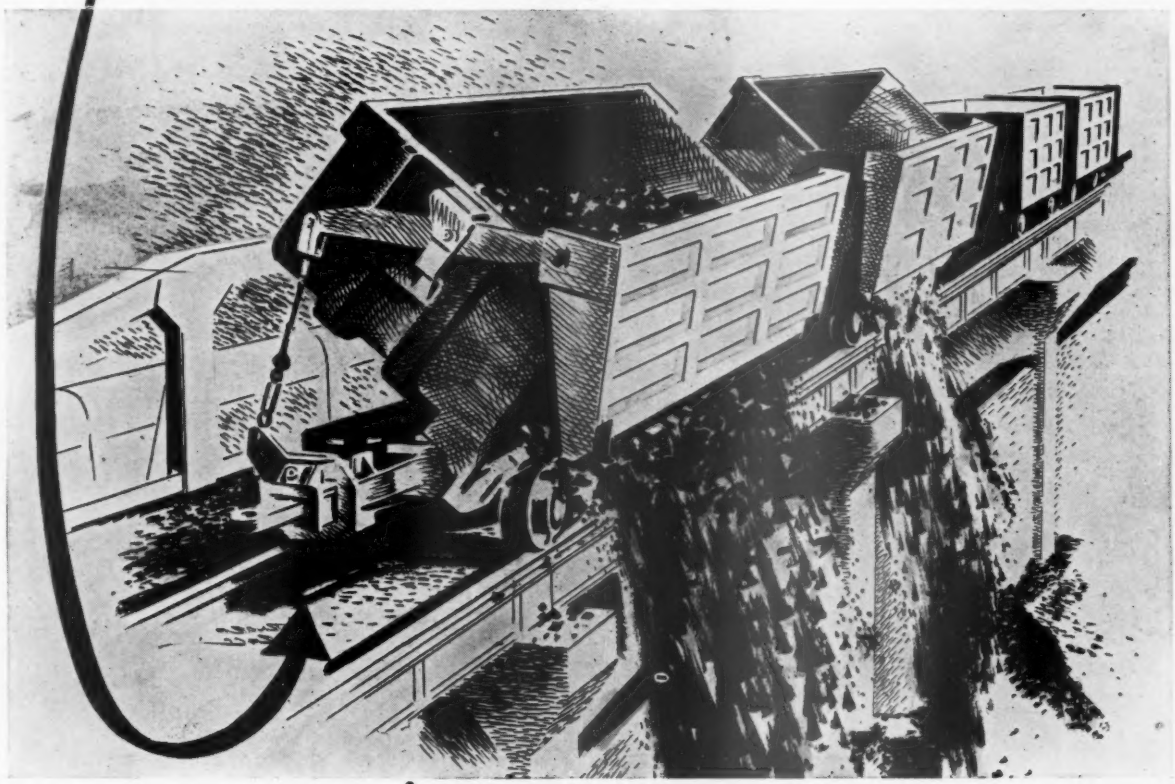


cast for an important part . . .

Consider the tough life of Ore Tipper Frames

Few vehicles have to undergo more continuous shocks and vibrations than ore carrying tipper trucks. Constant shunting and loading subject them to perpetual buffeting and optimum wear. It is because of the need for calculated, unfailing strength in the frames of the Granby tippers manufactured by Robert Hudson Ltd. (illustrated), that Lloyds with their unsurpassed facilities for scrupulous control at every stage of production are called upon to cast these vital components. These frames are cast as one complete unit for optimum strength.



TYPICAL LLOYDS STEEL SPECIFICATIONS USED FOR ROLLING STOCK COMPONENTS:

Grade S, 20.0% Carbon annealed, Yield Stress 14/18 t.s.i.; Ult. Stress 28/35 t.s.i.; Elongation 30/22%; R.O.A.% 45/30.

Grade M, 0.30% Carbon annealed, Yield Stress 16/19 t.s.i.; Ult. Stress 32/37 t.s.i.; Elongation 30/20%; R.O.A. 40/25%.

LLOYDS steel castings

Lloyds machine as well as cast

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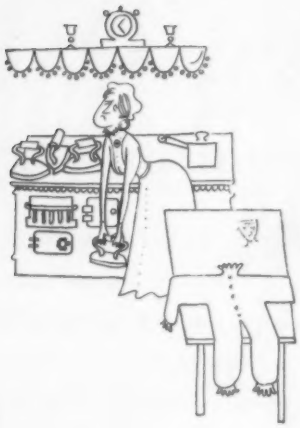

why pick on us?

. . . to iron out the little woman's problems

Because we're chivalrous enough to blench at the thought of her humping a heavy flat iron (it would lay *us* flat even to lift it); and ingenious enough to do something about it. Ingenious enough, in fact, to pressure die cast the really lightweight aluminium alloy sole plates for the latest Morphy-Richards irons. If *you* have a die-casting problem concerning aluminium alloys, perhaps we can iron that out too.

the whole in one

BRITISH DIE CASTING AND ENGINEERING COMPANY LTD.

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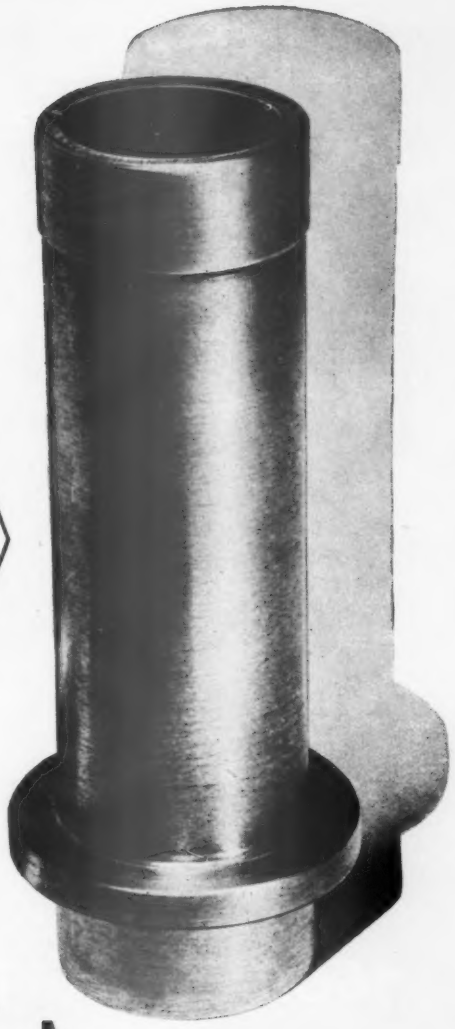
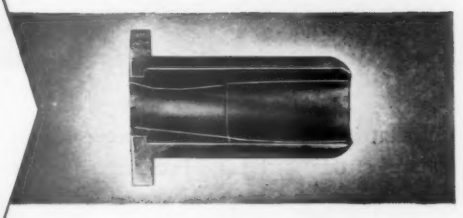
NOZZLES
outlast them all



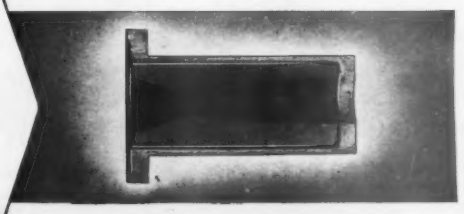
Seeing is believing !

The photographs below show the results of a comparative test made between a Tungsten Carbide Nozzle and a Carbon Tetra Boride Nozzle used with carborundum shot at an air pressure of 75-100 lbs per sq. inch.

The $\frac{3}{16}$" bore Tungsten Carbide Nozzle was worn to this condition in *two* weeks.



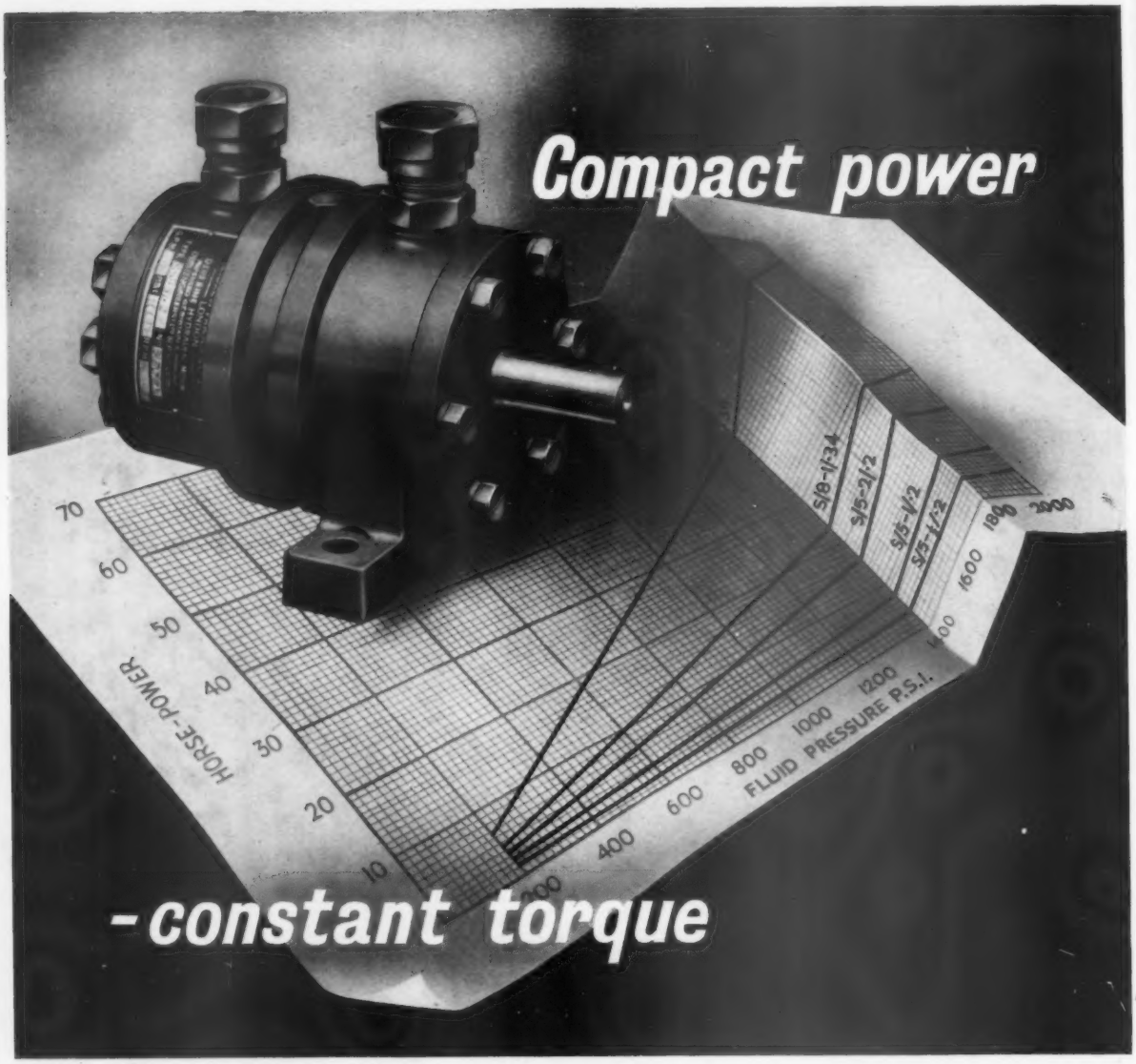
The $\frac{3}{16}$" bore Carbon Tetra Boride Nozzle with tapered lead-in was worn to this condition in *eight* weeks.



Glostics Ltd

AGENTS · IMPREGNATED DIAMOND PRODUCTS LTD

TUFFLEY CRESCENT · GLOUCESTER



Constant and full load starting torque is only one of the features of this outstanding hydraulic motor. It introduces high efficiency at low speeds and maintains it throughout the range, and provides exceptionally smooth transmission of power for a widely varied number of applications. Capable of rotation in both directions.

The smooth and vibrationless operation of the Motor is also a feature of the Deri-Sine Hydraulic Pump, a rotary displacement pump of high volumetric efficiency, which is essential to the power circuit.

An output of up to 4,000 lb./in. torque is available in a range of four basic sizes which incorporate variations in stator and rotor dimensions.

VALVES.—Mono-Radial Control Valves—built with precision and virtually foolproof—are arranged for one or more hydraulic supplies under manual, remote, or power operation.

for efficiency fit a FRASER DERI-SINE Hydraulic Motor

ANDREW FRASER & CO LTD 29 BUCKINGHAM GATE LONDON SW1 PHONE VICTORIA 6736-9

P778

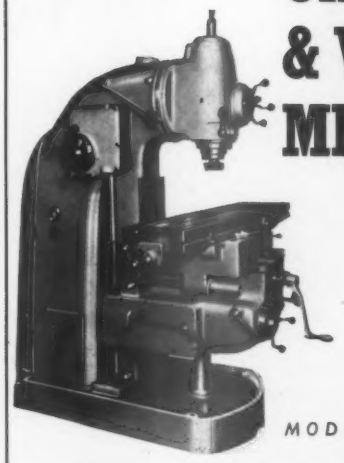
M A S

LATHE SN 20

EARLY DELIVERY

Swing over bed	15¾"
Swing over carriage	9 7/16"
Distance between centres...	39" or 59"
Spindle speeds in either direction (8) ...	32-1,000 r.p.m.

Universal & Vertical MILLERS

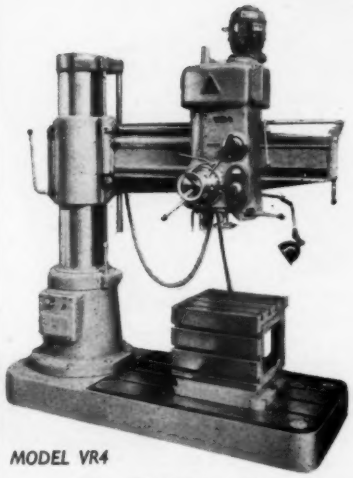


EARLY DELIVERY

MODEL FV2A

SPECIFICATION	FU2A UNIVERSAL	FV2A VERTICAL
Table Working Surface	53in. x 11¾in.	53in. x 11¾in.
Longitudinal Traverse — by hand	29½in.	31½in.
— by power	27in.	29½in.
Cross Traverse — by hand	12½in.	12½in.
— by power	11 13/16in	11 13/16in.
Vertical Traverse — by hand	17 11/16in.	17 11/16in.
— by power	15 11/16in.	15 11/16in.
	Table Swivels in both directions 45°	
Feeds:—		
Longitudinal & Cross	0.4in.-31in. per minute	0.5.-40in. per minute
Vertical	0.25in.-19in. per minute	0.3in.-24in. per minute
Motor H.P.	6	6

Radial DRILLING AMCHINES



MODEL VR4

Sole Selling Agents

MODEL VR2 EX STOCK

SPECIFICATION	VR2	VR4	VR6	VR8
Drilling Capacity in Steel	1in.	1 1/16in.	2⅛in.	3⅛in.
Drilling Capacity in Cast Iron	1⅛in.	2in.	3¼in.	4 1/16in.
Maximum distance centre line of spindle to column	31½in.	49in.	79in.	99in.
Minimum distance centre line of spindle to column	9in.	12 5/16in.	17in.	19⅛in.
Maximum distance spindle nose to Box table	24in.	30in.	52in.	64in.
Maximum distance spindle nose to base	40in.	51in.	72in.	83in.
Vertical movement of arm on column	21in.	28in.	34in.	41⅛in.
Taper in spindle	3 M.T.	4 M.T.	5 M.T.	6 M.T.
Spindle Speeds (12)	90-4,500	45-2,000	16-1,400	11-1,000
Spindle Feeds	(6) 85-850 cuts p. inch	(10) 16-1,020 cuts p. inch	(10) 13-820 cuts p. inch	(10) 11-720 cuts p. inch

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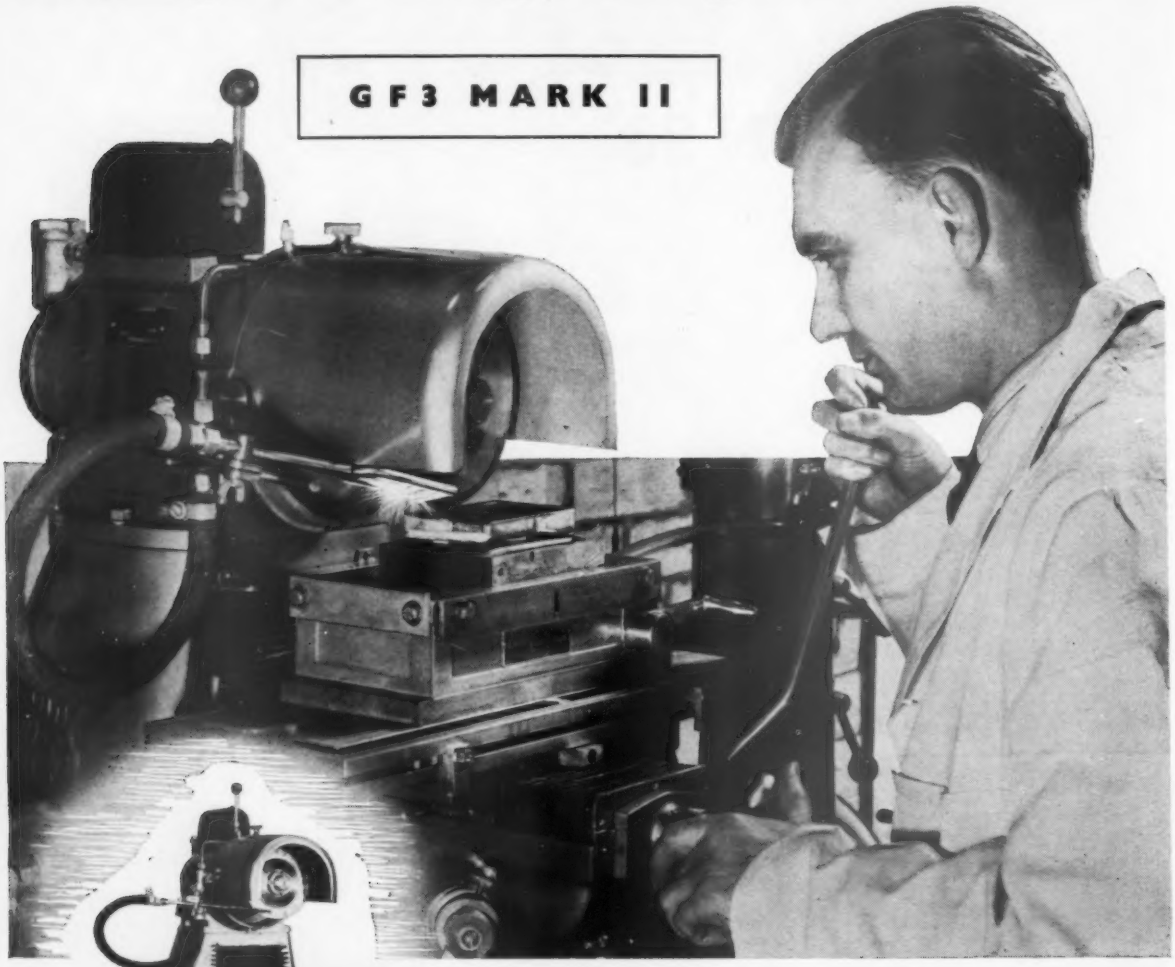
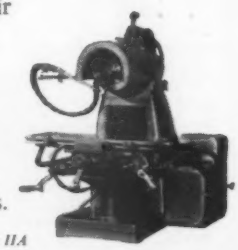
Cutting and tool grinding machine

GF3 MARK II



This bench model Universal Cutting and Grinding Machine can now be supplied in two forms, either with a manually operated traverse, or alternatively with an automatic traverse for the table. Specially designed by the manufacturers of Neven Diamond Impregnated tools for use with their products it is ideal for the tool room, laboratory or some production operations, and combines a high standard of precision with economy. Our Technical Sales staff will be pleased to arrange a demonstration or supply any further details.



Left: GF3 Mk II *Right: GF3 Mk IIA*

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DIXI '60' SWISS BUILT

HORIZONTAL PRECISION BORER

* ***EXCEPTIONAL ACCURACY***

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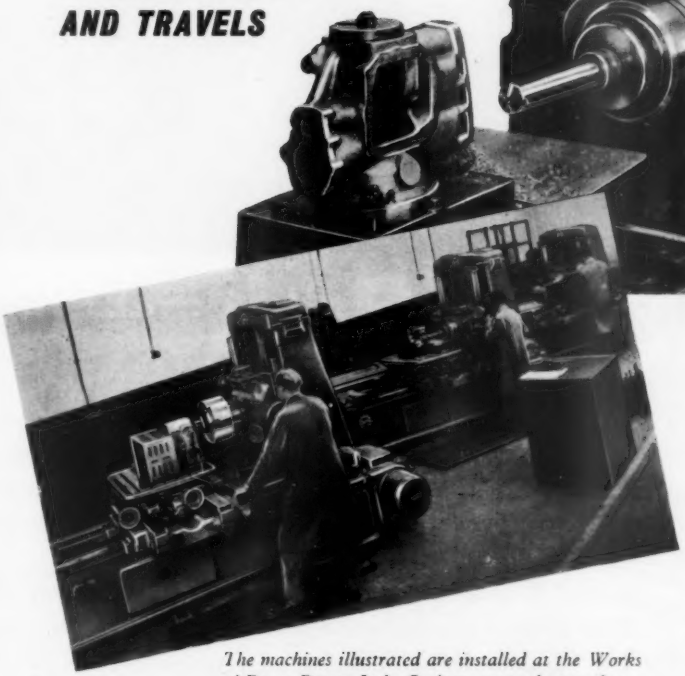
* ***INFINITELY VARIABLE SPINDLE SPEED AND TRAVELS***



The machines illustrated are installed at the Works of Bryce Berger Ltd., Staines, engaged upon the high precision production boring of intricate castings and forgings used for high priority work.

Design Features include:

All scales and dials clearly marked and equipped with optical microscopes for extremely fine settings.

Slide-ways hydraulically actuated.

Optical Precision Circular Dividing Table available, reading in seconds of a degree.

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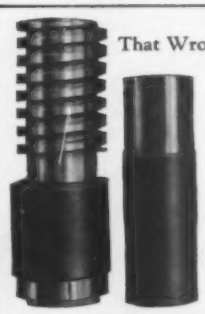

That Wrought Iron has outstanding machining properties is strikingly demonstrated by these typical test pieces. Its ductility is equally notable, while its essentially fibrous character gives it a toughness which enables it to stand up to severe vibrations, absorb varying stresses and recover from sudden shock.

Unrivalled in its ability to withstand shock and overstrain, Wrought Iron is renowned for its rust-resisting properties. Its natural susceptibility to welding is enhanced by slag inclusions; it is safer and more economical than mild steel for many long-term purposes — especially out-of-doors or under wet conditions.

Wrought Iron in strips and bars and in a variety of sections is produced at the Midland Iron Works for innumerable uses. A free copy of our Section Book will be sent on request, while our technical representative will be glad to advise you on any aspect of Wrought Iron usage.

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MR 111

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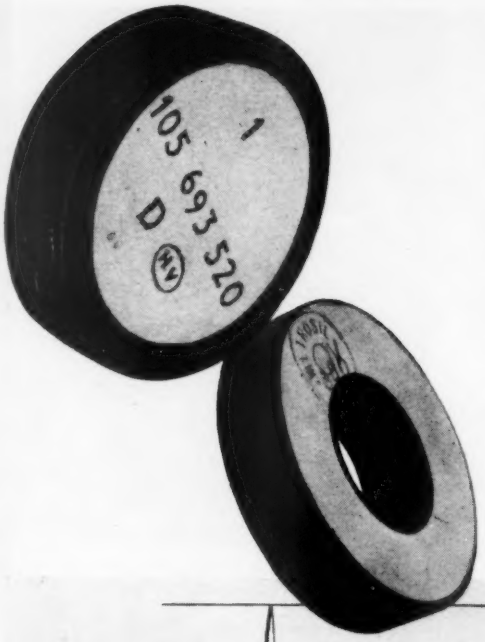
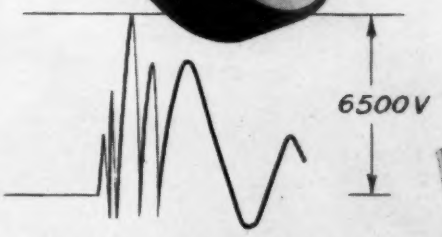
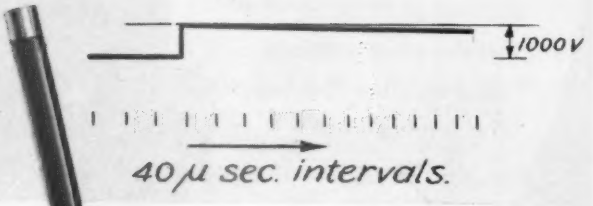


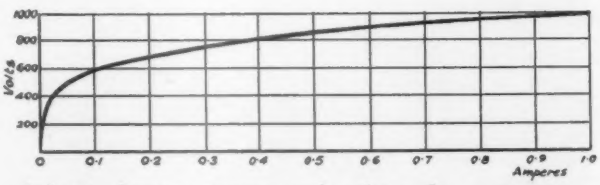
METROSIL

means protection against surge voltages





The non-linear volt-ampere characteristic of Metrosil resistors is exploited to provide a convenient means of safeguarding all types of electrical equipment against surge voltages. Based on silicon carbide, Metrosil is usually made in the form of discs, but rods can also be produced if required. These standard products are stable and convenient in size, standard discs ranging from $\frac{3}{8}$" to 6" in diameter. Typical applications for Metrosil products include the protection of field coils, relay coils and solenoids, instrument relays, condensers, tap-changing switches and power transmission lines. Other applications include spark quenching, protection of instruments under fault conditions, relay sensitivity improvement, etc. Please write for full technical details.



Relation between current and voltage for a typical "Metrosil" disc, examples of which are illustrated at the top of this page.

METROPOLITAN-VICKERS

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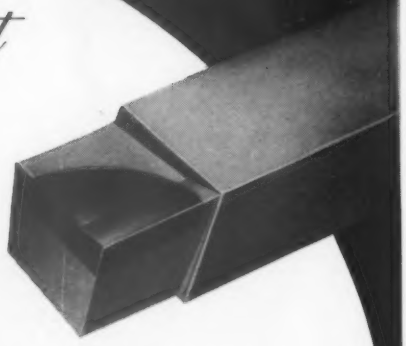
Hard and fast

the story of Cutanit★ tips and tools

Cutanit
a Metro-Cutanit Product



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The formation of a solution of tungsten carbide in titanium and tantalum carbides is an important process in the manufacture of hard metals. Such a formation involves a change in the atomic structure of the carbides which must be kept to a certain pattern. X-Ray apparatus is constantly in use, making absolutely sure that this process maintains the unequalled efficiency of finished Cutanit tips and tools.

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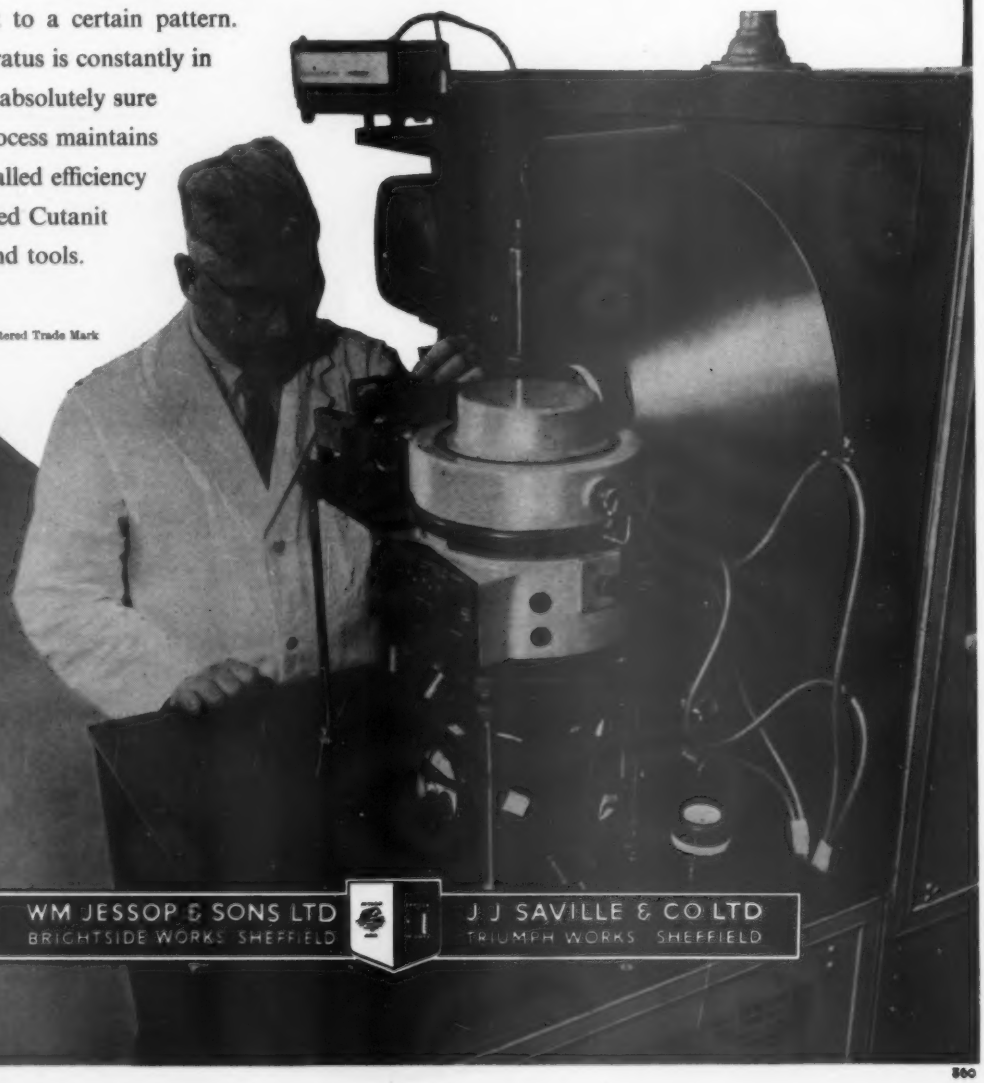

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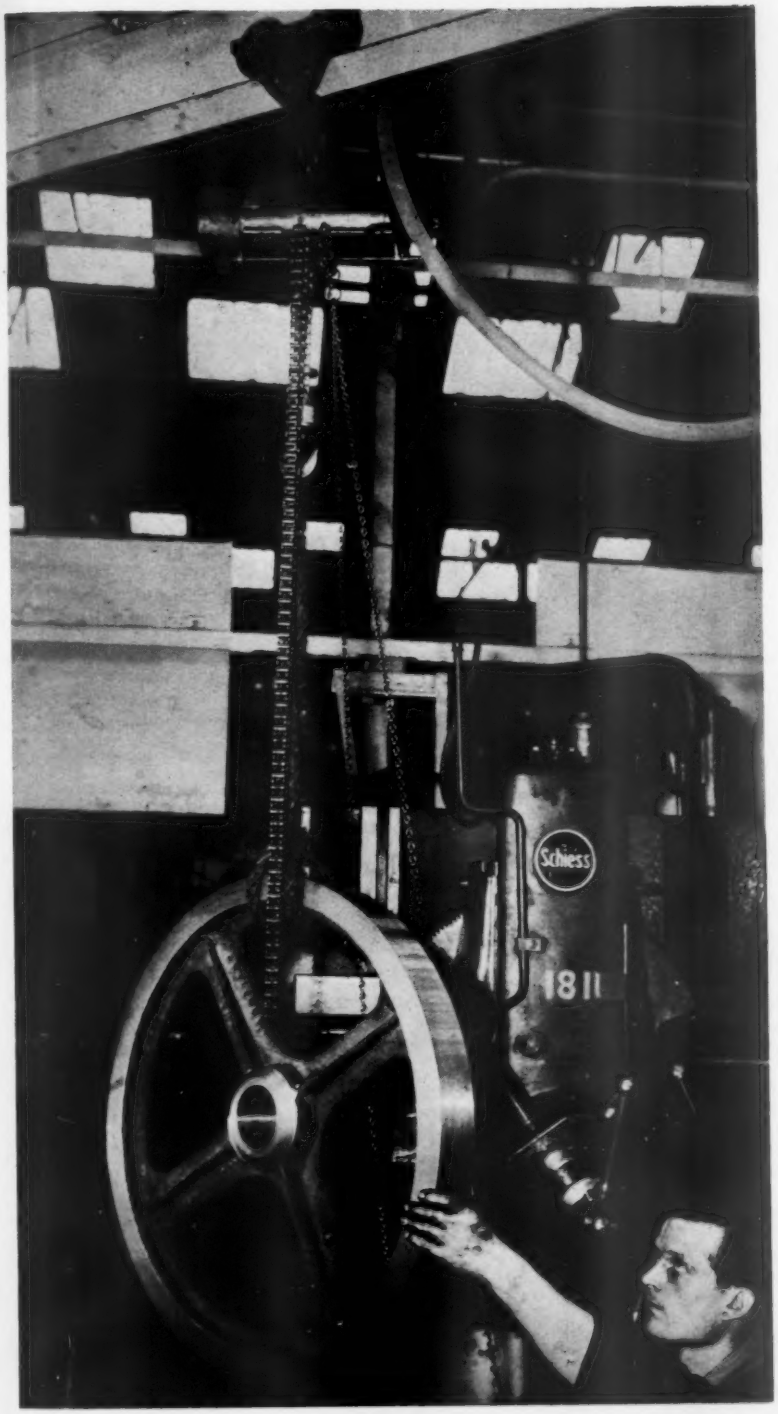

Photograph by courtesy of Messrs RUSTON-BUCYRUS LTD.

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The value of "BROOMWADE" pneumatic hoists as time and money savers is recognised by the leading industrial companies.

Robustly constructed, yet light enough to be easily carried by one man, "BROOMWADE" hoists can raise half-a-ton at a speed of 26ft. per minute. Control is by means of a highly sensitive throttle valve which varies the speed of lift from inching to the rated maximum.

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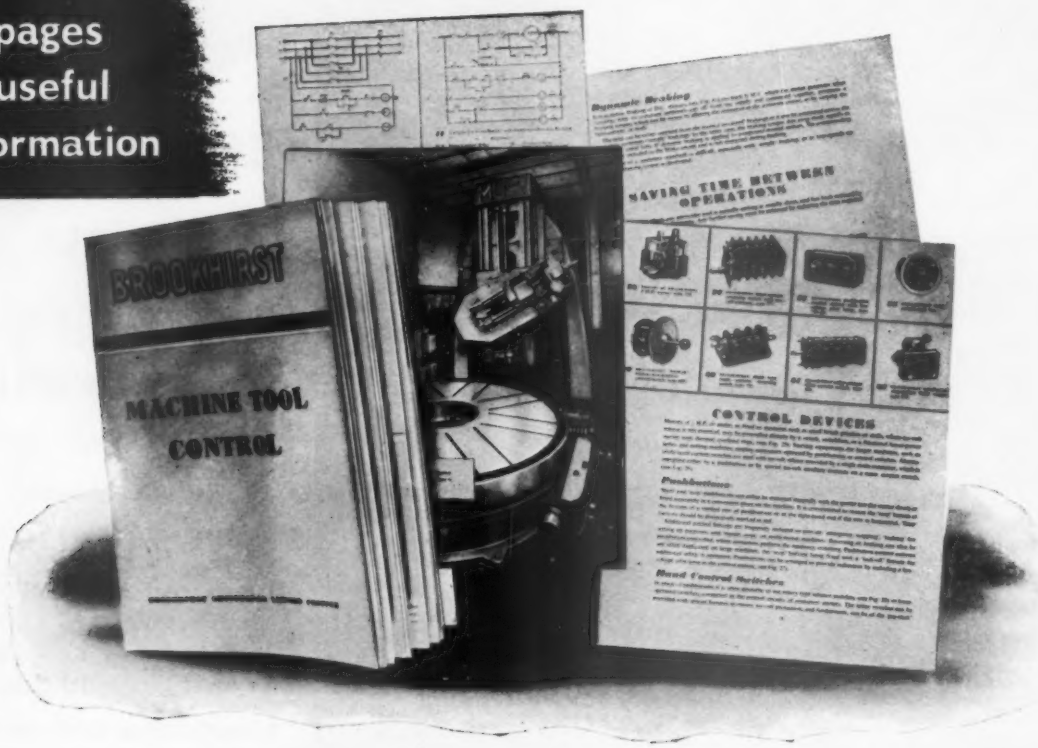

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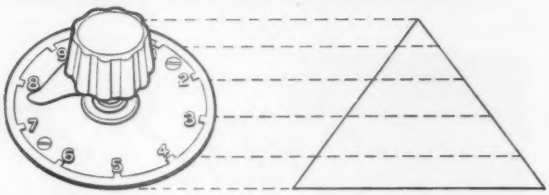

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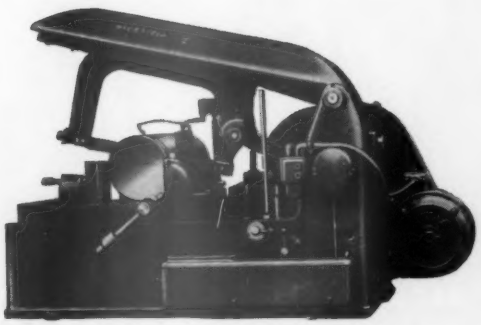
The blade commences and finishes each cutting stroke with no pressure whatsoever. What a saving in blades!



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Particulars of these instruments will be found in our catalogue MODERN INSPECTION EQUIPMENT, a copy will be sent on request.

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THE HILGER UNIVERSAL PROJECTOR shown here combines the functions of a projector and a precision measuring machine reading to ·0001". It can be supplied for surface projection to deal with obscured forms. The precision protractor, graduated 90° on either side of zero reads directly to 1 minute.

All interested in inspection are invited to visit our Measuring Department at Coventry where the application of modern inspection equipment can be studied.

Full particulars available from:—

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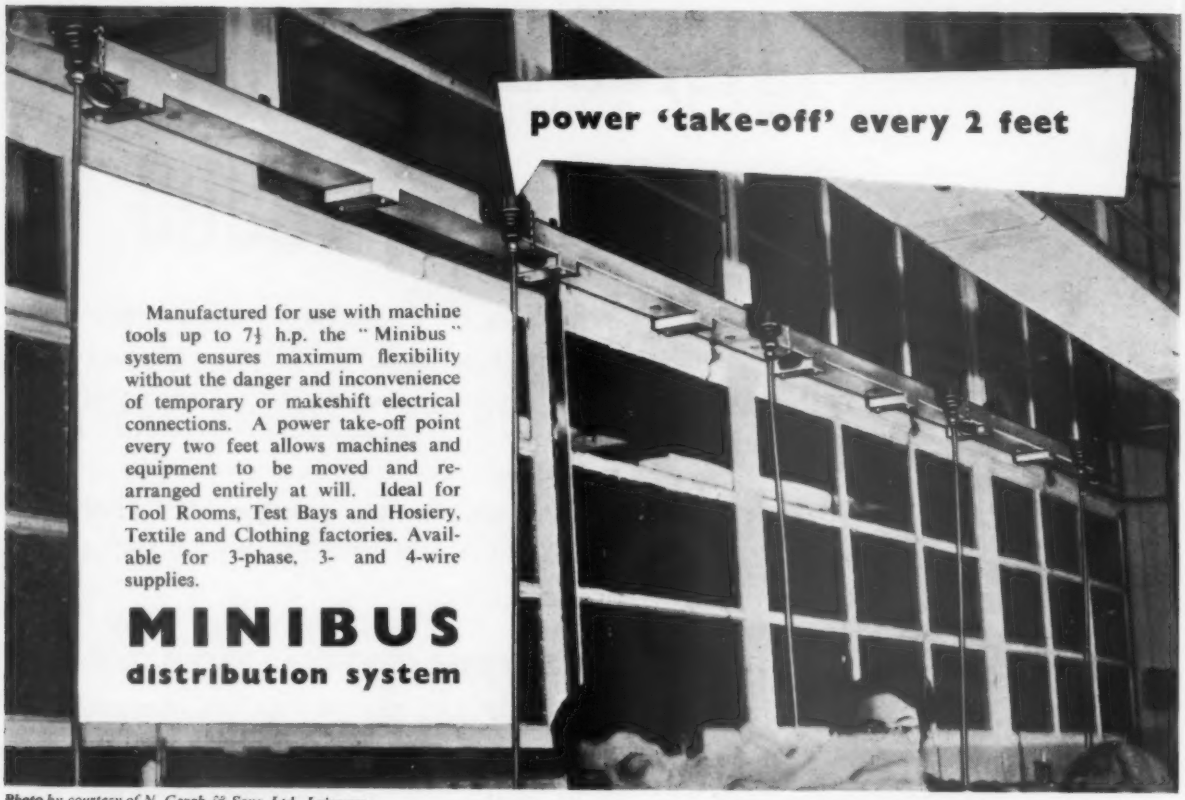
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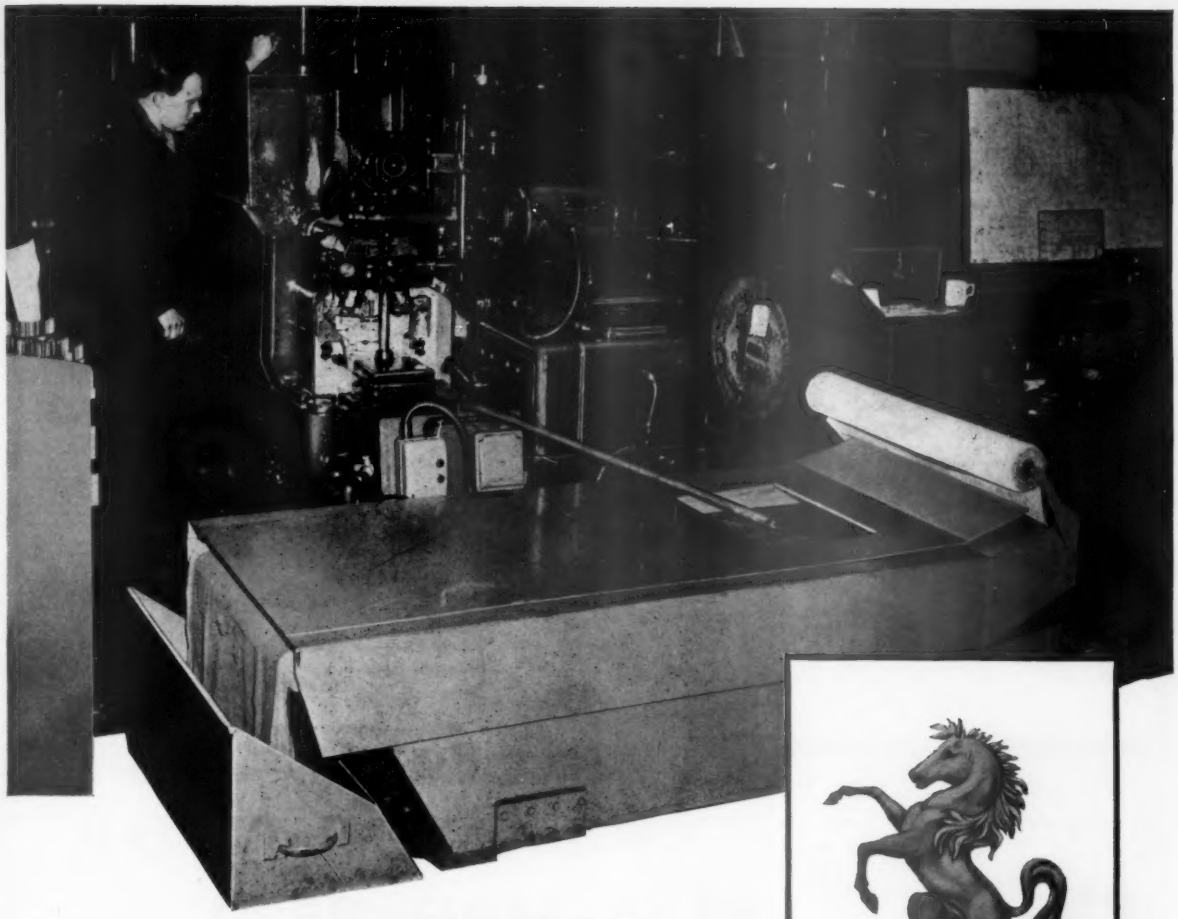

Reproduced by courtesy of Aveling-Barford Limited.

Messrs. Aveling-Barford of Grantham, the originators and world's largest manufacturers of road rollers were the first 'Filtrall' users to employ a unit for filtration of neat cutting oil in their gear grinding section.

The installation has resulted in improved production time—increased output—longer grinding wheel life—superior component finish and considerable economy in the use of cutting oil.

Our Filter Sales Division will be pleased to advise you on your filtration problems and will arrange for a trial of a suitable unit in your works without obligation.

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The articles are coated by dipping in molten CROCELL (160°-185°C) for 5 seconds. The coating solidifies within seconds and can be set aside to cool. CROCELL can be removed at any time by slitting the skin and peeling off in much the same manner as a bananna skin. If required the skin can then be returned to the dip-tank and used again.

The normal film thickness is 0.06 ins., when CROCELL will coat approximately 3.45 sq. ft. The film thickness can be varied to some extent by the method of application.

CROCELL can be supplied in colours if required and can also be supplied conforming to M.O.S. spec. CS 2486. Details of a full range of dipping-tanks are available upon request.

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anti-corrosive specialists

Full information about CROCELL and other anti-corrosive coatings can be obtained from the makers.

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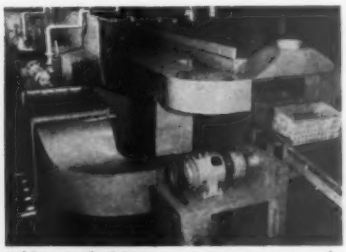
Bratby

HERE ARE THREE EXAMPLES

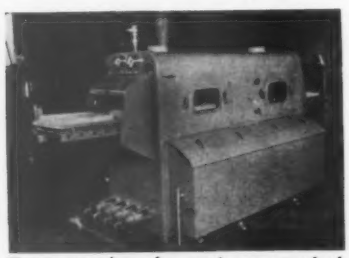
INDUSTRIAL CLEANING MACHINES

can be designed to meet your particular cleaning problems

This illustration shows a machine cleaning crank cases in the production line. It is equally capable of cleaning small parts in baskets.



A 'power' driven conveyor system is employed with this cleaning machine for ball bearings.



Trays carrying the work are pushed through on a roller conveyor by hand in this cleaning installation.

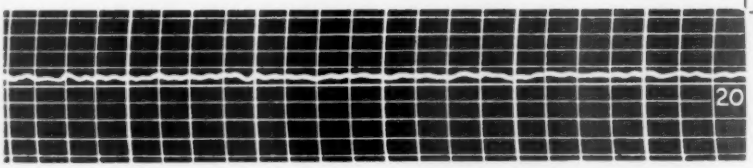
Whilst offering a very wide variety of standard cleaning equipment, it is BRATBY policy, wherever possible to design the machine to meet the particular cleaning problem. Careful study of each individual problem ensures maximum efficiency and economy of the plant in operation. The illustrations show but a few of the specific types of Cleaning Machines designed by BRATBY for individual needs.

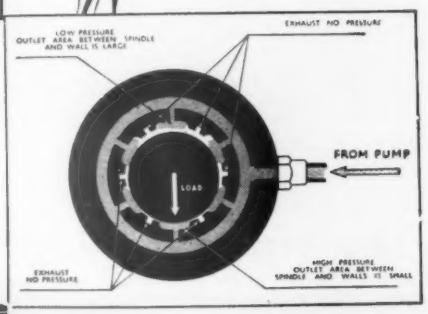
Designed and Manufactured by:

BRATBY & HINCHLIFFE LTD. SANDFORD ST · ANCOATS · MANCHESTER 4

Stanley Howard says....

THIS LAMB'S WOOL FIBRE HAS BEEN MAGNIFIED 1,000 TIMES



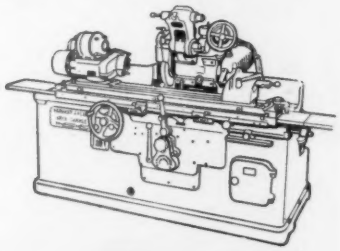


The "heart" of this amazing machine is the "fluid bearing" of the "GERARD" grinding head in which different pressures are built up in adequate areas, the variation of these pressures being controlled only by the position of the spindle in relation to its bearing, regardless of angular velocity.

AND THAT'S ONLY ONE-FORTIETH THE MAGNIFICATION OF THIS SURFACE DEPTH VARIATION PRODUCED BY A

Gendron Freres

External and Universal Grinding Machine



The specimen illustrated above gave a "TALYSURF" reading of .4 μ (centre line average) with a vertical magnification of 40,000 and a horizontal magnification of 200.

But that's not all—a "TALYROND" check of the same specimen gave a result of only .00001" out of roundness.

Further information can be obtained from the Sole Distributors →

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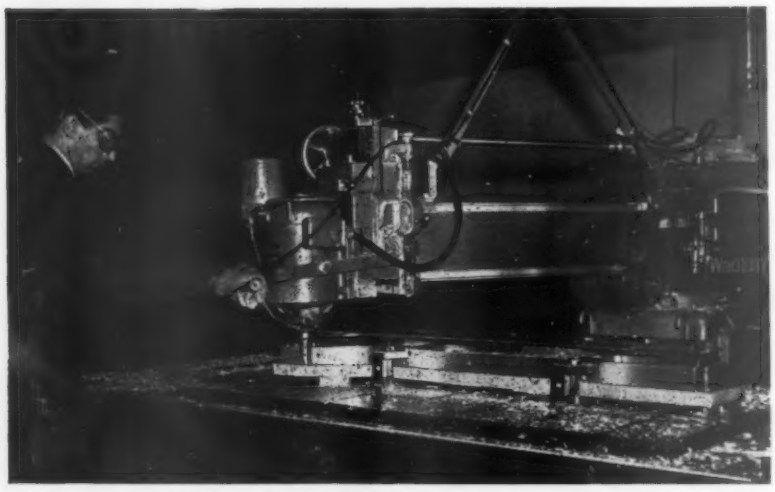
The fastest method of profile milling non-ferrous metals



Photograph by courtesy of Messrs. Vickers-Armstrongs Ltd. Swindon.

If your work calls for milling components out of a solid plate of light alloy it would pay you to learn more about the Wadkin Heavy Duty Router L.Y.R. Although relatively inexpensive this machine will remove a large volume of metal at much faster rates than the orthodox type of milling machines. Not only does this Wadkin reduce actual cutting times but because of cutting speeds up to 18,000 r.p.m., only light clamping is necessary and floor to floor times are considerably reduced.

Why not let us demonstrate the amazing possibilities of the new Wadkin Heavy Duty Router on your own work ?

Wadkin

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Certified...

.....Zinc Alloy Die Castings

The British Standards Institution, in collaboration with the Zinc Alloy Die Casters Association, has introduced a certification scheme for zinc alloy die castings. Under this scheme, zinc alloy die casters may be licensed by the B.S.I. to use the Kite Mark ♈ on their castings as a guarantee that they are produced under strict analytical control and subject to inspection by the B.S.I., and that they comply with British Standard 1004.

Certified castings normally bear the Kite Mark ♈, "B.S.1004" and the die caster's name, trade mark,* or B.S.I. licence number. To ensure complete satisfaction we recommend that, on all your orders, you should specify: 'Certified zinc alloy die castings'.

**Indicated in the illustration above by the star.*

At the time of printing Z.A.D.C.A. members licensed to operate the scheme included:

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ALLOY PRESSURE DIE PRODUCTS LTD., WILLENHALL.
ARMSTRONG PATENTS CO. LTD., BEVERLEY.
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Well suited to high speed drives these joints can be used where tension and compression loads occur and often eliminate the need for telescoping sleeves. They are made from 45-50 tons alloy steel to Air Board specification, with hardened steel trunnion blocks.

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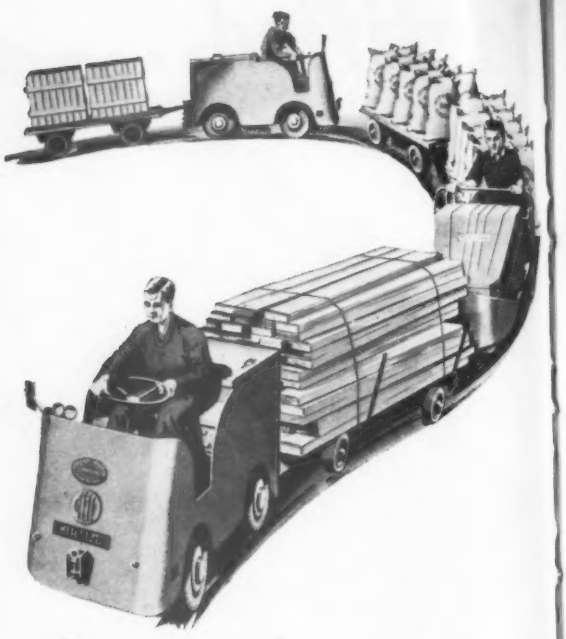
PHONE: ELMBRIDGE 0033-7 GRAMS: PRECISION SURBITON



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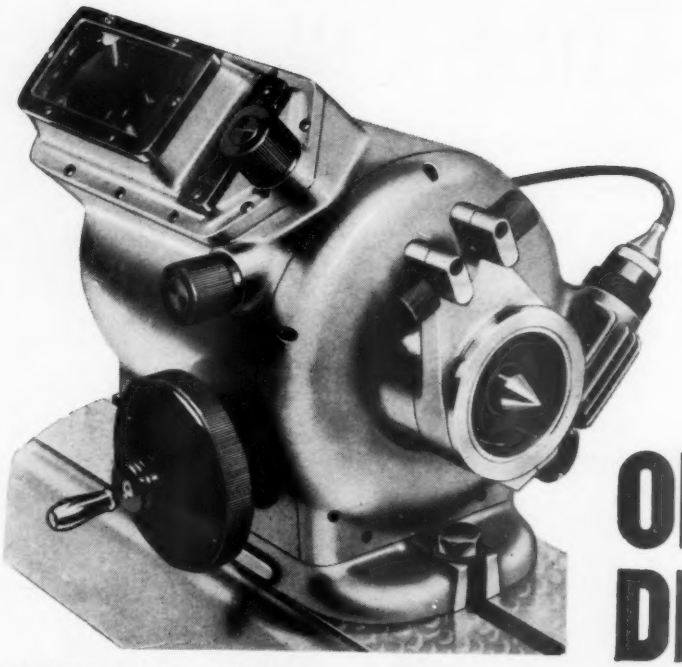

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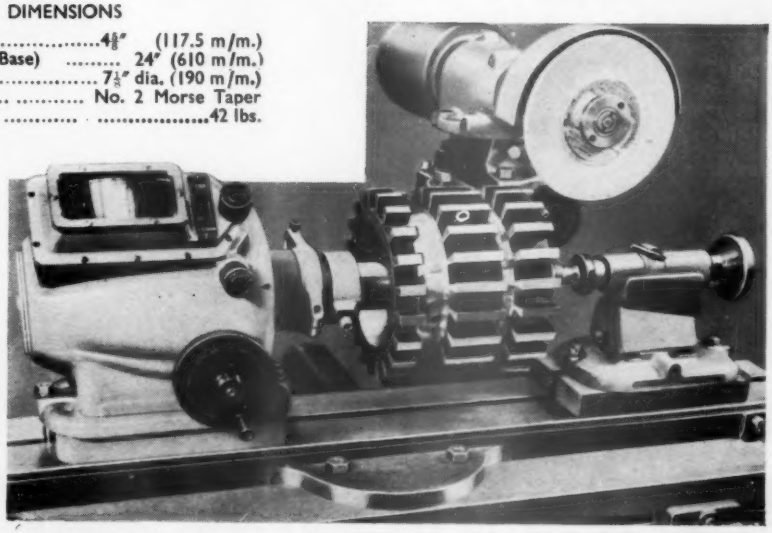
Size of Face Plates	7½" dia. (190 m/m.)
Size of centres	No. 2 Morse Taper
WEIGHT OF HEAD	42 lbs.



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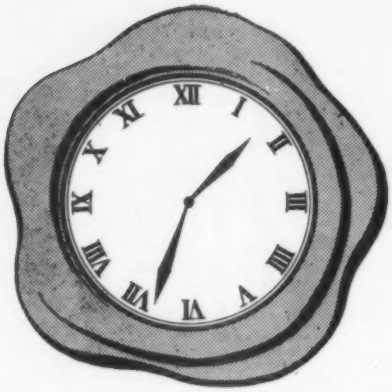

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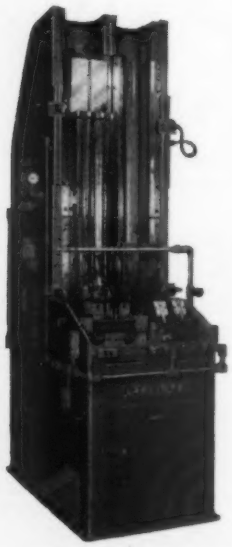
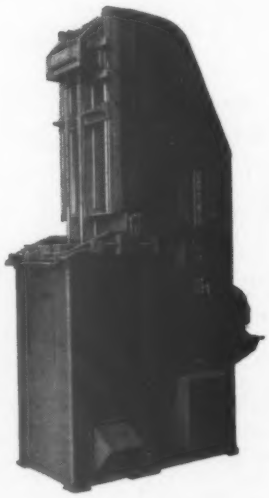


10 ton 66" D.R.V.
Double Ram Surface
Broaching Machine



20 ton 68" V5
Vertical Internal
Broaching Machine

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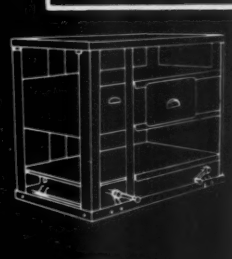
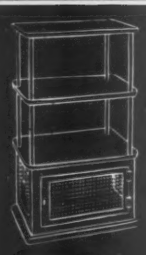
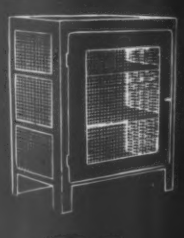


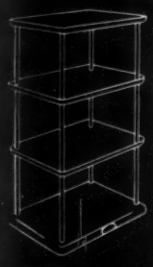
TYPE 111
WORK BENCH



TYPE 165
TOOL STAND



TYPE 170
TOOL LOCKER



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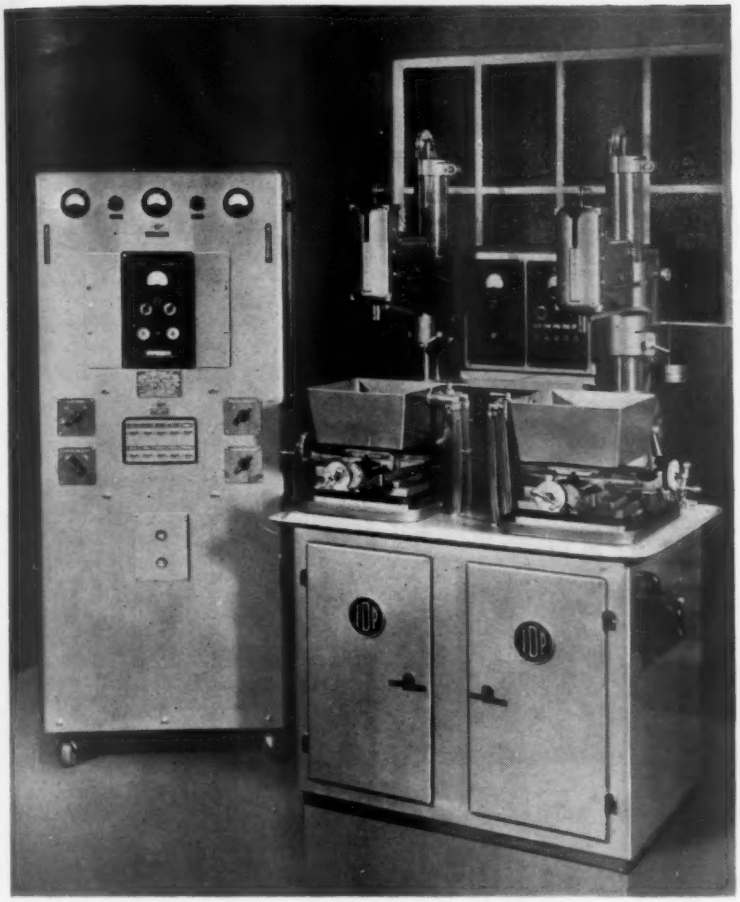

For production of all types of dies and form tools.

The leading manufacturers of spark machining equipment in the world, have pleasure in announcing their latest

SPARCATRON Mk. II Model

With double head.

This addition to the Sparcatron range of machines for spark machining has been produced as the result of requests for an equipment for use with large section electrodes to be operated to very close limits, and can be supplied with two heads as illustrated, or with a single head.

The twin head model can be easily worked by one operator, and the heads operated separately, so that production per man hour is doubled.

A further two or more heads may be used in conjunction with the main control unit in some circumstances.

Manufactured by:

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A machine tool is only as good as the oil that lubricates it. The choice of oil therefore not only determines the efficiency of the machine in operation, but also the length of its productive life.
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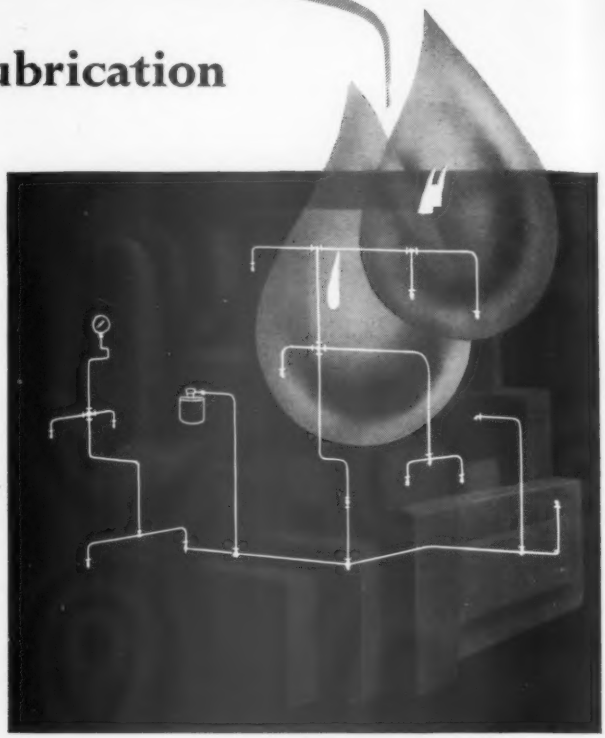

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Some acid comments on
structural plastics

a new lightweight challenge to chemical attack

Light, strong mouldings of structural plastics are resistant to a very wide range of chemicals and could successfully be applied to many liquid storage and piping problems. They can cut costs all along the line, being relatively simple to mould in quantity, light to transport and to handle on the site, where they can be stored—if necessary in the open and for long periods—without fear of deterioration. Battery boxes for aircraft; pipes and containers for acid solutions; drain pipes; developing tanks; brine pipes, vats and storage tanks—are these indeed practical applications? B·I·P—the polyester people—do not yet claim to know all the answers, but would gladly co-operate with you in putting structural mouldings to the acid test.

What are structural plastics?

Structural plastics consist of a reinforcing agent, such as glass fibre, bonded with a synthetic resin, most commonly a polyester type resin. Polyester/glass fibre mouldings can be made either mechanically or by hand fabrication and their essential characteristics are . . .

Lightness combined with strength—specific strengths comparable with steel.

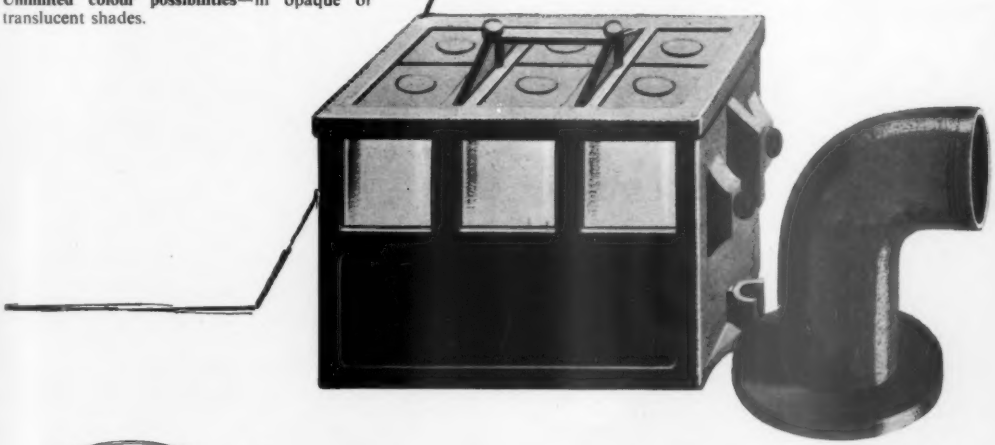
High resistance to corrosion by a wide range of chemicals, including some acids, and to all but excessive heat.

Excellent electrical properties—high breakdown and low power factor, combined with good insulating and non-tracking properties.

Unlimited colour possibilities—in opaque or translucent shades.

Consult **B·I·P** *Services*

B·I·P—makers of the highest quality polyester resins—gladly offer the full resources of their ***Research, Development and Design Services*** *to manufacturers interested in the potentialities of structural plastics.*



B·I·P Chemicals Ltd · Oldbury, Birmingham · *Telephone:* Broadwell 2061

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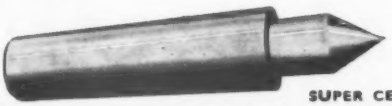
BE RIGHT IN THE CENTRE



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A permanent Hardened and Ground Socket with RENEWABLE HIGH SPEED STEEL INSERT. Standard inter-changeable inserts enable centre to be quickly replaced.

STANDARD SOLID CENTRES

Precision ground to give perfect concentricity. Tapers to standard gauges. Made in High Grade CARBON ALLOY STEEL, or HIGH SPEED STEEL BUTT WELDED.

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All types of centres are made from the best grade steel, and are designed to give greater efficiency. Take higher speeds, and remain true under the most strenuous conditions of present day engineering.

FOR LISTS NOS. 50B and 85

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REVOLVING CENTRES

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ARCHER SMALL TOOLS

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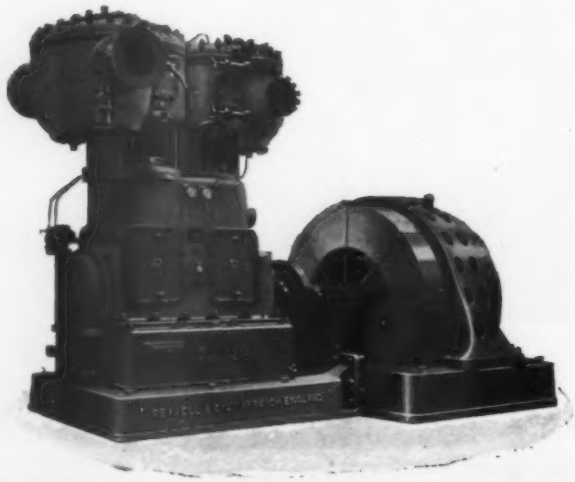
WHEN YOU ARE WANTING NEW

AIR COMPRESSORS

DO NOT FORGET THAT WE HAVE

A COMPLETE RANGE TO SUIT ALL DUTIES



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34" Archdale

VERTICAL MILLING MACHINE

with combined sliding and swivelling head . . .

This massive, powerful and versatile machine, with its sliding and swivelling head, makes light of heavy duty die and tool work at the Enfield Cycle Co., Ltd., Redditch. Table has reversible automatic feeds and quick-power traverse in all three directions. Speeds and feeds changed from front of machine. Direct reading dials. Twelve speeds from 29/520 r.p.m., or alternatively 36/638 r.p.m. Twelve feeds, ¾in. to 20in. per minute. Quick and fine hand adjustment to spindle, which swivels through 90°. Table working surface 53in. × 14½in.

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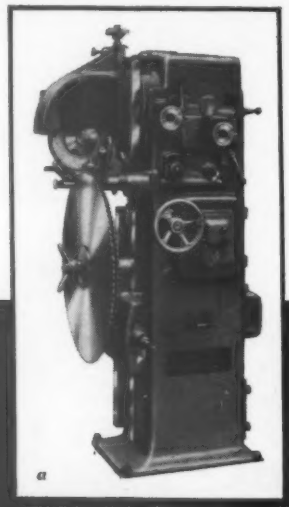

a

The Russell Hydrofeed range includes :

• Straight and angular cutting models • Automatics • Verticals • Special Billet cutting models

Patented Features :

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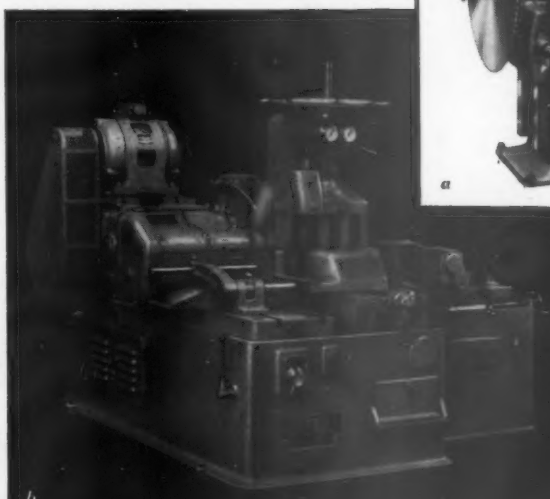

b

a SAW SHARPENING MACHINE
Capacity 11" to 48" blades

b 'HYDROFEED' COLD SAWING MACHINE
Automatic bar feed

S. RUSSELL & SONS LIMITED
LEICESTER, ENGLAND

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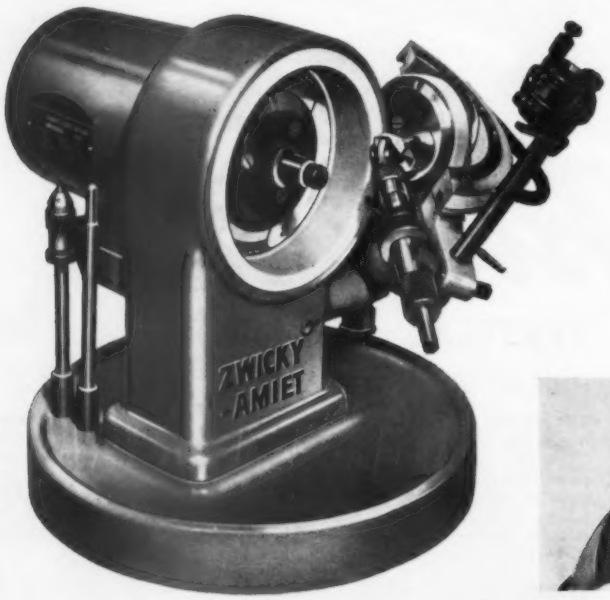
The 'ZWICKY-AMIET' PRECISION DRILL GRINDER

MODEL 03-6



for drills of diameter ranging from

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left hand, right hand or straight flute;
Point angle from 60° to 180°;
Cutting angle from 0° to 30°;
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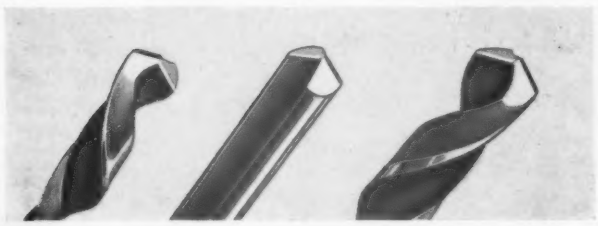
The drill is ground on the FOUR-FACET principle, which gives a keen, clearly defined cutting edge as shown below:-



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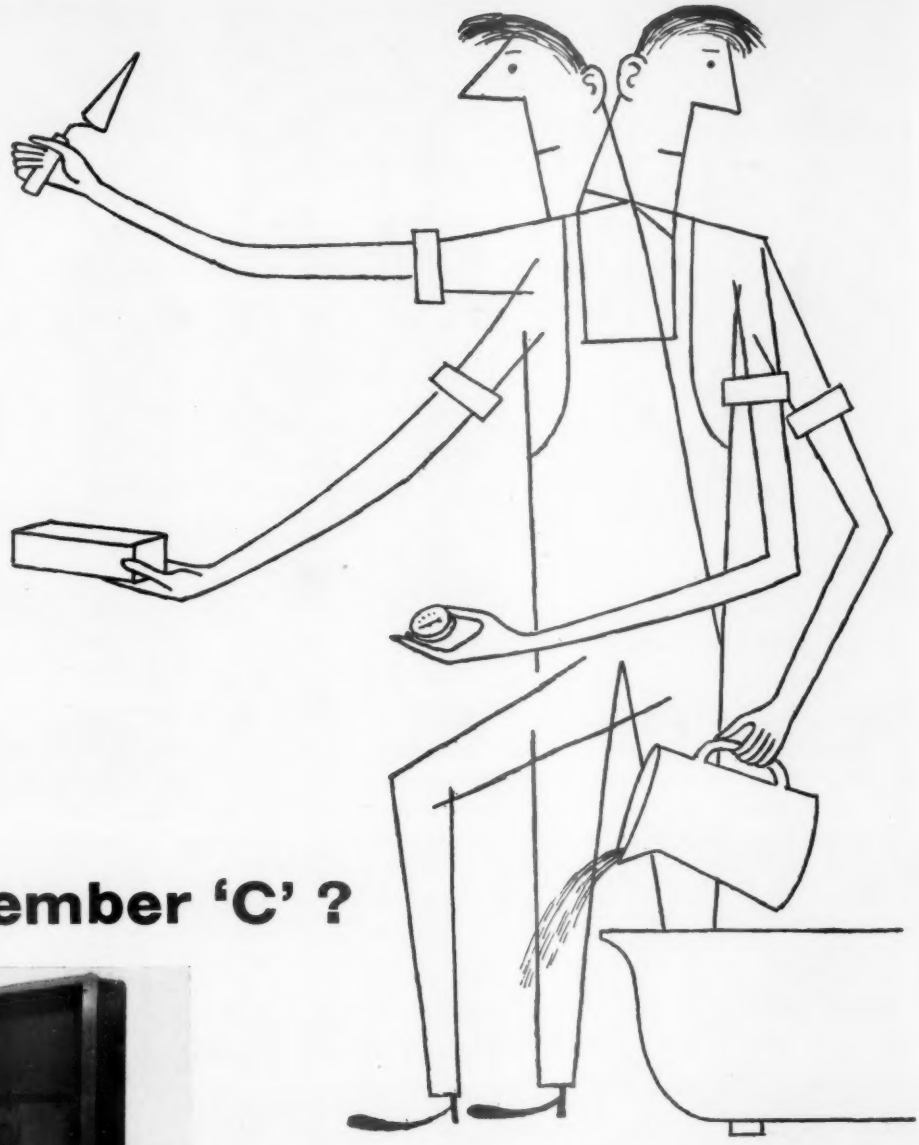

Remember 'C' ?

Cables and wiring are attached to switchgear cubicles and other electrical plant by means of clips fastened by stud welding. This leaves a smooth outer surface besides speeding construction of these units.
(Courtesy of George Ellison Ltd.)

C was the man who always had to do the almost impossible. If A and B were filling a bath with water in six minutes, C had to let it out in three . . . if A and B laid 288 bricks in two hours, C had to lay 576 in one . . .

We would have liked to have known C. We could have helped him. By introducing him to stud welding we would have shown him how to get the better of A and B and do the work of as many as five men in the time of one.

If you've got a C on your production line, call in

THE STUD WELDING ORGANISATION

Crompton Parkinson LIMITED

ELECTRICAL EQUIPMENT

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TRADE MARK

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Richard Lloyd Limited

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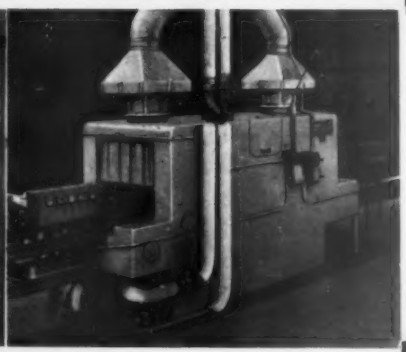
PRIOR TO ASSEMBLY, and BEFORE and AFTER REPAIRS

Supplied for the washing and drying of Tractor parts. Crank Shafts, Sumps, Pressings, etc.



A model 'A' machine, washing parts of motor car engines prior to assembly.

Dawson Metal Parts cleaning machines are supplied for all branches of the engineering industry. Their chief characteristics are robustness of design, small number of working parts and simplicity of operation. Space only permits the illustration of four of the many types of machines built for quick economical washing and drying of Metal Parts.

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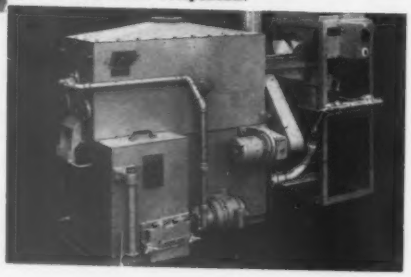
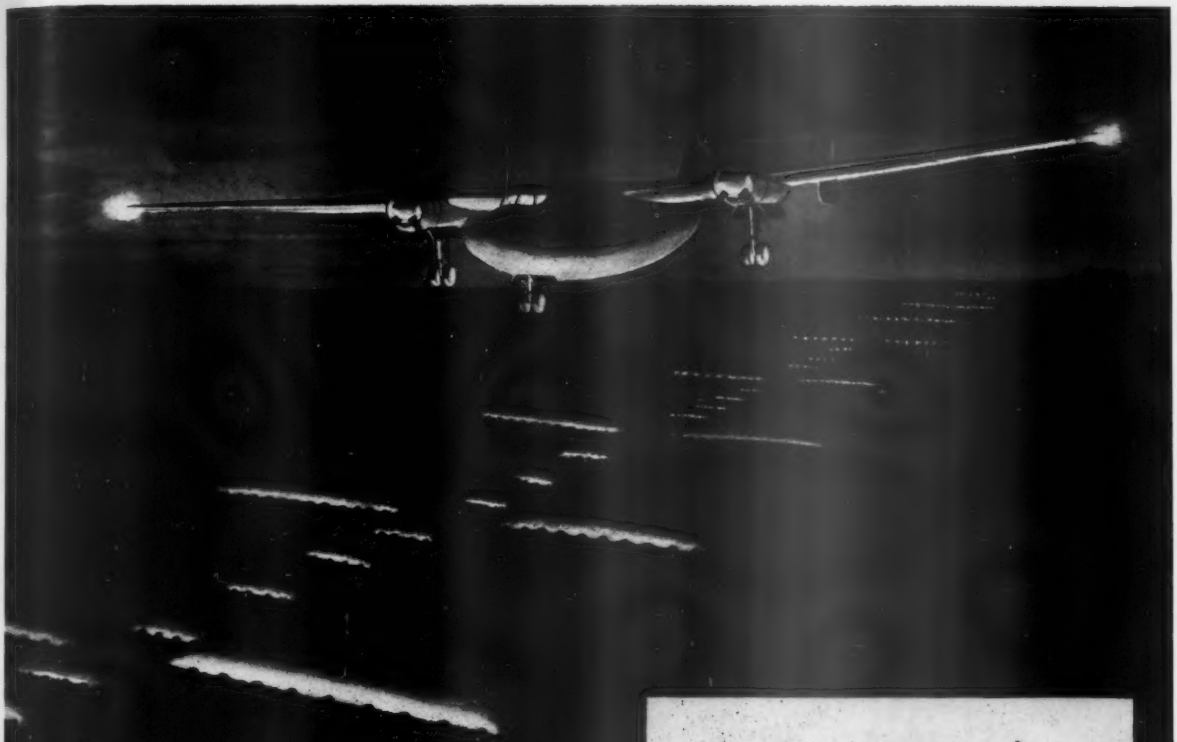
A 'Junior' type machine supplied to a Midlands Motor Car Works

Dawson

DE-GREASING MACHINES

A Rotary Drum machine for removing swarf and grease from small components.





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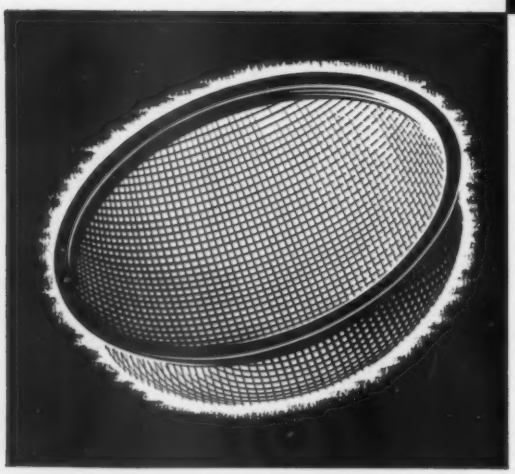

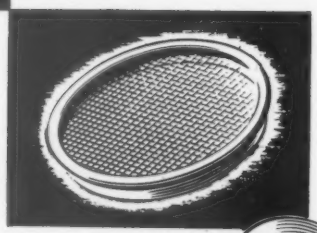

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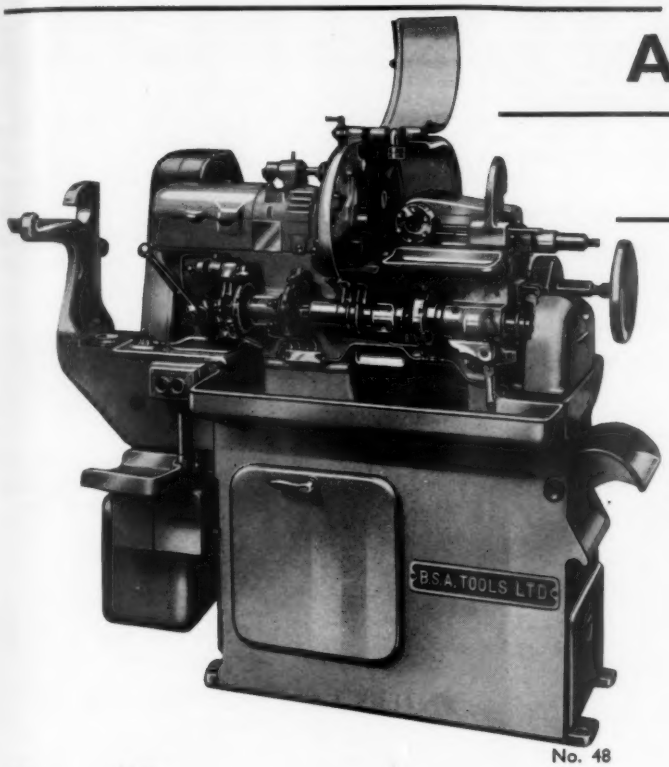

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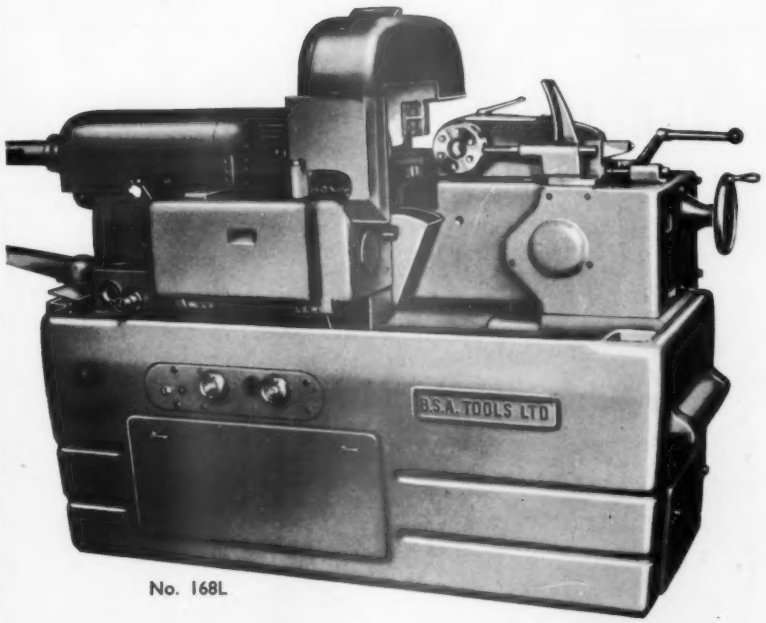

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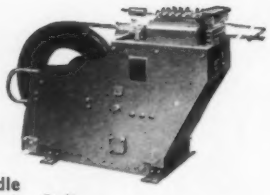

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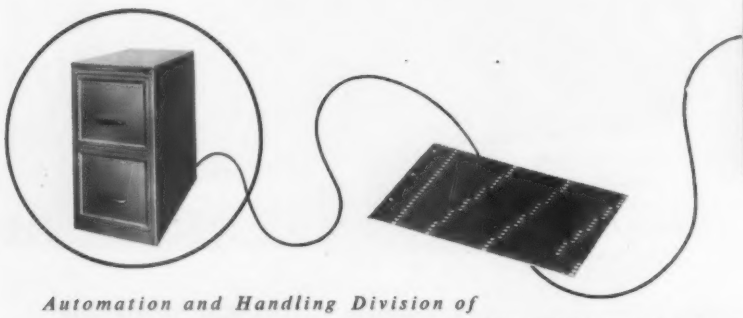

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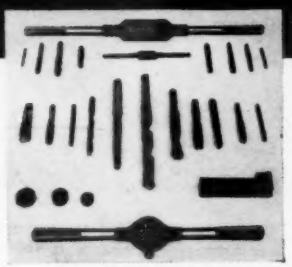

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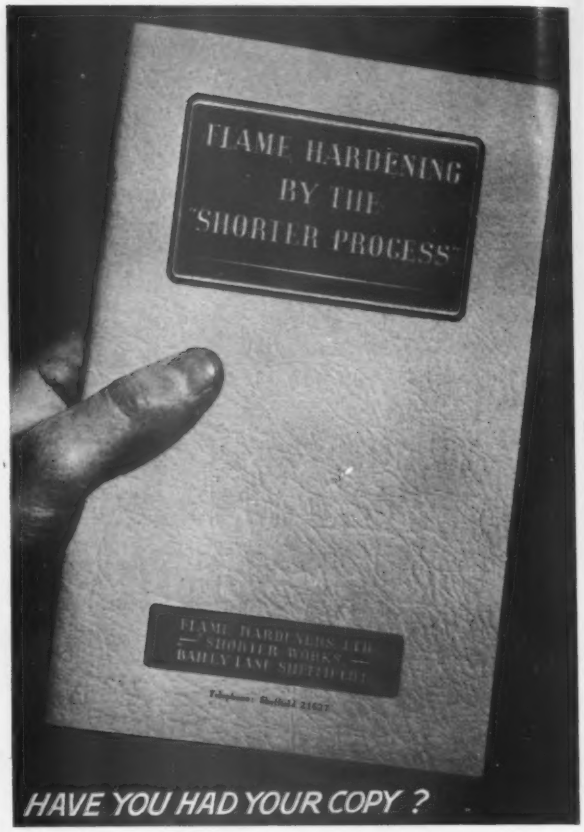

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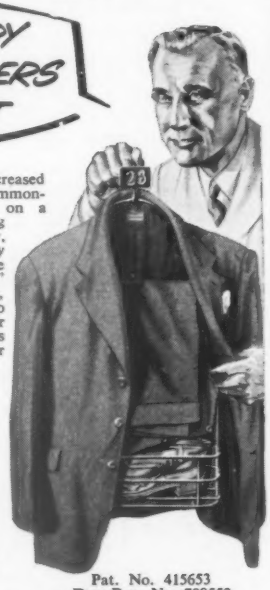

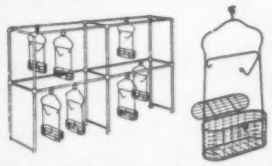

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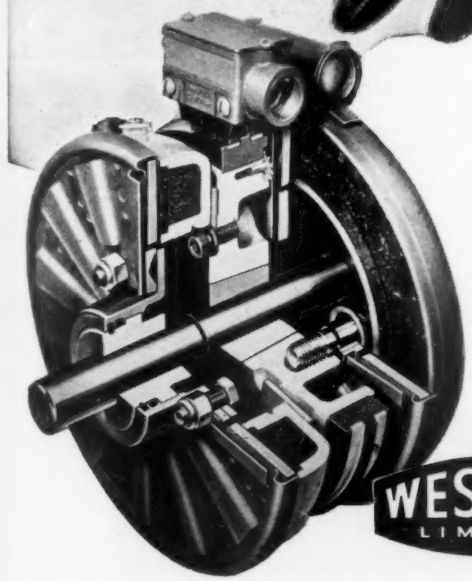

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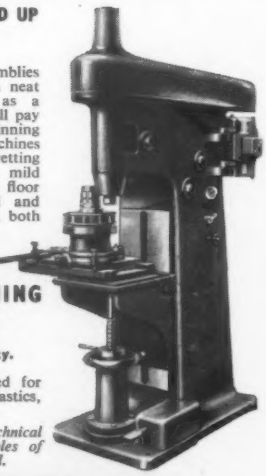

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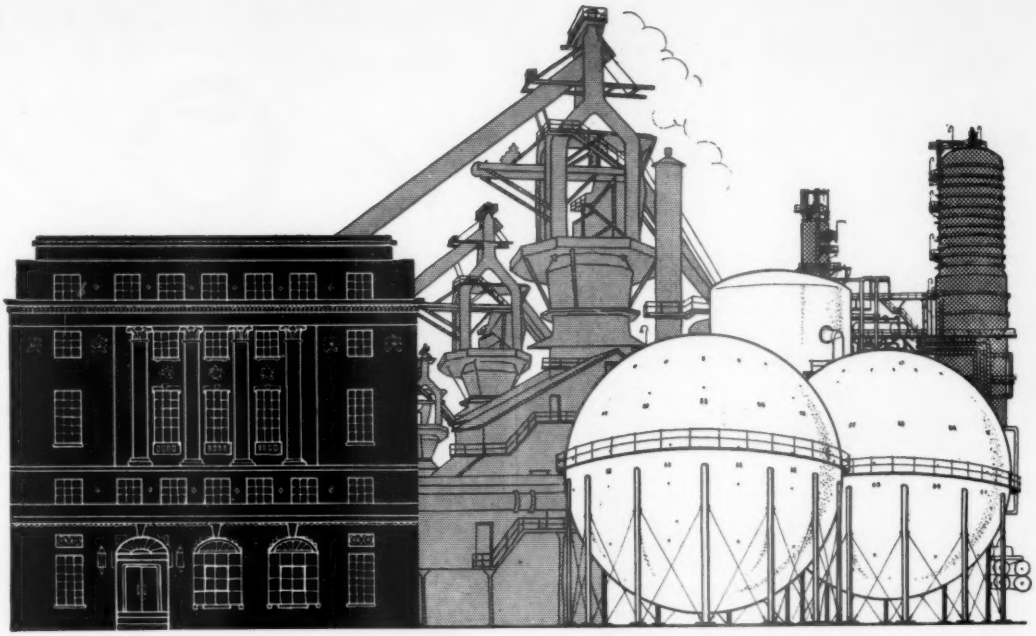

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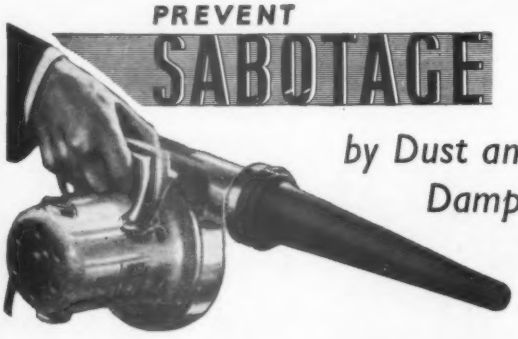

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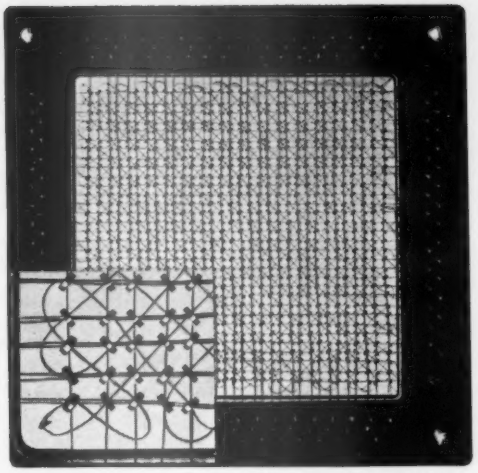

A typical magnetic matrix store with enlarged portion showing Ferroxcube 2 mm diameter 'D2' cores in position.

with FERROXCUBE 'D' GRADE CORES

Memory storage devices using magnetic cores have many advantages over alternative systems. They will store intelligence for an indefinite period without consuming power; they permit intelligence to be rapidly withdrawn sequentially or otherwise; and they are extremely reliable.

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Ferroxcube D1 is particularly suitable for use in magnetic shift registers and other switching devices.

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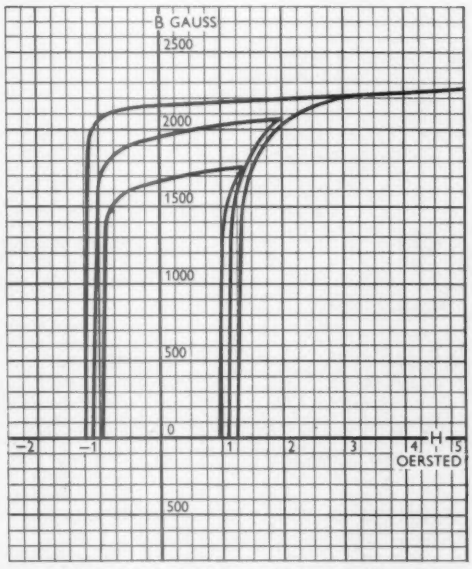
Full details of Mullard Ferroxcube 'D' grade cores will be gladly supplied on request to the address below.



General form of the hysteresis loops of Ferroxcube 'D' grade cores.

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'Ticonal' alloy permanent magnets
Magnadur permanent ceramic magnets
Ferroxcube ferro-magnetic cores.

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All communications regarding advertisements should be addressed to the Advertising Managers, T. G. Scott & Son, Ltd.
Crown House, 143-147, Regent Street, London, W.1. Phone: Regent 3891.
Printed by Maxwell, Love & Co. Ltd., White Lion Street, London, N.1.

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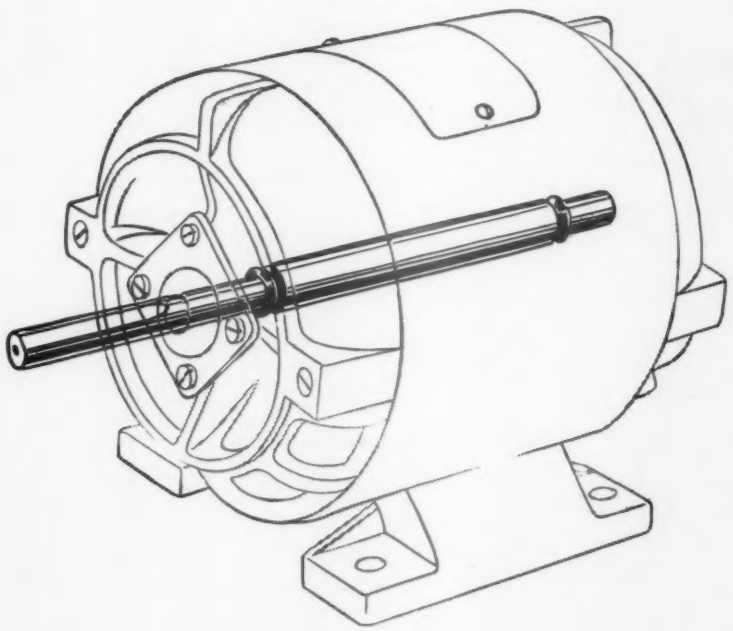

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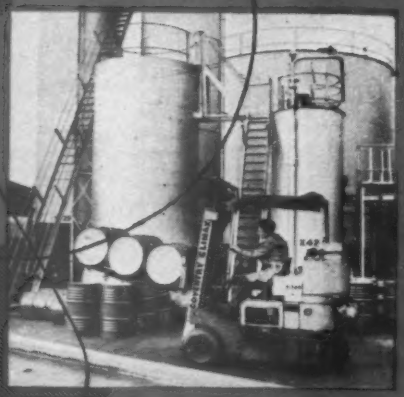

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JOURNAL SUPPLEMENT

Vol. 34, No. 7
JULY, 1955

INSTITUTION OF PRODUCTION ENGINEERS, 10, CHESTERFIELD ST., LONDON, W.1

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THE MARGATE CONFERENCE-PUBLICATION OF PROCEEDINGS

As announced in the July Journal, there will shortly be available in book form a full report of the Margate Conference Proceedings. Members of the Conference will receive one copy free of charge ; other copies will be available to members and non-members at 25/- each, post free.

As there is already a considerable demand for this report, those who would like to reserve a copy are invited to complete and return the order form overleaf as soon as possible.

THE ANNUAL DINNER

The Institution's Annual Dinner will take place on Wednesday, 12th October, 1955, at the Dorchester Hotel, London. Order forms for tickets will be circulated with the August issue of the Journal, but in the meantime members are asked to make a note of the date.

COVENTRY SECTION DINNER DANCE

The Coventry Section of the Institution are holding their Annual Dinner Dance on Friday, 14th October, 1955, at the Masonic Hall, Coventry. The reception will be at 7.30 p.m. for dinner at 8 p.m., and dancing will take place until 2 a.m. A licence has been obtained until 1 a.m. Tickets, which are 27/6 each, may be obtained from Mr. W. P. Gill, c/o S. Gill & Sons (Engrs.) Ltd., Lythalls Lane, Coventry.

MARGATE CONFERENCE — PUBLICATION OF PROCEEDINGS

To: The Secretary,
Institution of Production Engineers,
10 Chesterfield Street,
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Please reserve for me .....copy/ies of the bound publication of the Proceedings of the Margate Conference at 25/- each, post free. I enclose £..... in payment.

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PLEASE .....

All remittances should be made payable to "The Institution of Production Engineers"

PRODUCTION APPOINTMENTS

BULLETIN No. 58
JULY 1955

The last date for receiving material for insertion in the following month's bulletin is the 20th of each month.

The fee for insertion of particulars regarding each appointment is £3 3s. (up to 100 words), and over 100 words £5 5s. A standard charge of £1 1s. per insertion is made to firms affiliated to the Institution, Technical Colleges, Universities and similar organisations.
Advertisers are advised that better response is likely if, in addition to essential qualifications, the following information is given:—

(*a*) Location of appointment; (*b*) Status in the organisation and scope of promotion; (*c*) Salary range and age range.

Advertisers are asked to advise the Institution when appointments are filled. The Institution reserves the right to refuse or withdraw any announcement and also to make any alteration in the wording to ensure conformity with the Institution standards. *Members interested in the following appointments should make application in accordance with the terms of notice. No correspondence can be undertaken by the Secretary other than the forwarding of replies to Box Nos.*

All advertisements appearing in this Bulletin are subject to the Notification of Vacancies Order of 1952.

Time and Motion Study Engineer to take charge and reorganise the time study section of a modern engineering works engaged in the machining and assembling of automobile components. Only engineers having had at least five (5) years experience in scientific time and motion study need apply. Salary £900 - £1,000 in accordance with experience. This is a permanent staff appointment, pensionable, and with opportunities for advancement for an experienced and ambitious engineer. Factory located 30 miles north of London where rented housing accommodation is available. Box No. 1114, I.Prod.E., 10 Chesterfield Street, London, W.1.

Planning Engineers required, must have previous experience of production planning in medium light electro mechanical engineering field. Salary commensurate with ability. Please apply: The Personnel Manager, Messrs. Elliott Bros. (London) Ltd., Airport Works, Maidstone Road, Rochester, Kent.

Mechanical Design Engineers required for development department of The Morgan Crucible Co. Ltd. Work is connected with development of light machines and equipment for the production and testing of a wide range of products based on carbon, graphite and clay. Projects are handled from conception to completion and offer scope for inventive ability. Preference will be given to applicants with practical works training and holding O.N.C. or higher qualifications. The position is permanent and pensionable. Five-day week. Applications, which will be treated in complete confidence should be sent to: The Staff Manager, Battersea Church Road, London, S.W.11.

Planning Engineers. A number of vacancies for both senior and junior engineers of proved ability who have specialised in either (a) machine shop work or (b) sheet metal work. Applicants should have a sound practical knowledge based on extensive shop experience in the aircraft engine or similar industry. Please write, giving full details of experience and education to: The Personnel Officer, The de Havilland Engine Company Limited, Leavesden, Nr. Watford, Herts.

First-class Gear Production Man required for Oil Engine Division. Initial duties to supervise process planning and advise on tooling for gears on Oil Engine work. Subsequently to control gear production on shop floor, and be responsible generally for high quality output. Modern factory, pension scheme. Excellent salary to tip-top man with wide knowledge of this class of work. Send full details of experience, salary expected, etc., to: Labour Manager, (F), Messrs. Rolls-Royce Limited, P.O. Box 31, Derby.

Graduate Engineer is required by a progressive British Company as Technical Assistant to the Chief Engineer of one of its modern processing factories. Many problems of a technical nature arise, and the successful applicant will take responsibility for handling these. The responsibility is clearly defined and initial training over many months will be given to prepare the new man for the position. A good degree in mechanical engineering and some basic workshop training is necessary. The Company is prepared to delay the appointment should the right applicant not be immediately available. Age limit 28 years. This position is a starting point in the organisation and an excellent commencing salary will be paid to which will be added

substantial increments in line with his progress and development. In judging applicants the Company will be looking at the man's development possibilities, both technical and administrative as the Company has a long record of healthy growth and wants its new men to be capable of growing with it. All factors such as superannuation scheme, etc., are available to suitable candidates who should send, in confidence, a brief outline of their career to date to: Box No. 1120, I.Prod.E., 10 Chesterfield Street, London, W.1.

First-class Work Study Engineer is required by a major Clyde shipyard to co-ordinate and develop incentives in the yard workshops. Duties will include practical shop floor study work and the training and supervision of ratefixers in several trades. Suitable applicants will probably have had comprehensive and responsible experience of ratefixing in general engineering and will have a thorough knowledge of work study techniques. The position offers wide scope for a competent and adaptable man. Box No. 1121, I.Prod.E., 10 Chesterfield Street, London, W.1.

Toolroom Superintendent required for factory in Bombay-India, engaged on production of electrical laminations. Applications are invited from men with necessary experience and qualifications. Further details will be given at interview. Reply stating full particulars, age, experience, etc. Box No. 1122, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant Works Manager required for established factory in Bombay-India producing electrical laminations. Applications are invited from men possessing the necessary administrative and technical qualifications in production of the above. Further details will be given at interview. Reply stating full particulars, age, experience, etc. Box No. 1123, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Manager. Applications are invited for appointment as Production Manager to a large engineering company in the London area. The Company is concerned with the manufacture of chemical plant and compressing plant. Applicants should have a sound knowledge of ferrous and non-ferrous fabrication, and should be experienced in all aspects of works administration. The post offers excellent salary and opportunities, together with all the advantages of an appointment with an international organisation. The Company has ideal welfare conditions including a pension fund. Should the successful applicant be resident outside the North London area, assistance may be given in providing housing accommodation; removal expenses will be paid. Applications giving full details of age, qualifications, experience and present salary to: Box No. 1124, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Planning Engineer required by growing company having products covering wide range of machining, fabrication, painting and assembly. Must be experienced and competent in all branches of production engineering including modern factory methods, planning, jig and tool design, progress. Knowledge of materials handling an advantage. Company situated in pleasant country district one hour West of London. Canteen facilities. Please write, giving age, past experience, married/single, present salary to: Box No. 1125, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineers — Henry Wiggin & Co. Ltd. Manufacturers of nickel alloys, wish to engage staff for their work study departments in Birmingham, Glasgow and Hereford. The need arises in consequence of the proposed enlargement of these departments and the promotion of several senior work study engineers to managerial positions. Applicants must be first-class work study engineers, having (a) a sound education, (b) at least five years experience of work study and the practical application of payment by results to production maintenance and service departments, and (c) a personality suitable for this type of work. The appointments offer wide scope and will be limited to keen and progressive men. A very good salary will be paid commensurate with the experience and high standard required. A non-contributory pension scheme is in operation. Apply in writing to: The Managing Director, Henry Wiggin & Co. Ltd., Wiggin Street, Birmingham, 16, giving full details of past experience, employers, education and qualifications.

Young Engineer. Venesta Limited require a young engineer for their expanding factory in Calcutta. Applicants should be about 25 years of age, having served a good engineering apprenticeship and be Graduate members of either the I.Mech.E. or I.Prod.E. Attractive terms include basic salary equivalent of £1,300 per annum, plus free living accommodation, medical expenses and other allowances. The post offers scope and a promising career to the right man, who would be expected to contribute to pension fund and provident fund. Applicants, who must have good general education and background, should write to: The Personnel Manager, Venesta Limited, North Woolwich Road, London, E.16, giving full details of education and experience.

Senior Engineers. L. W. Bailey & Partners, Industrial Consultants, invite applications from senior engineers age 30 - 45 to join their staff. Applicants must be of pleasing personality, reasonably mobile and have held executive posts in industry. Specialised experience in floor layout, materials handling or methods engineering techniques is desirable and corporate membership of an appropriate professional Institution would be an advantage. Salary in accordance with experience and qualifications. Apply in writing, giving full details to: L. W. Bailey, 28 Anselm Road, Hatch End, Middlesex.

Ambitious man required for Drawing Office of Machine Tool makers in the West Midlands. Applicant to be capable of developing and taking charge of special machine project. Apply, stating age, experience and salary required. Box No. 1126, I.Prod.E., 10 Chesterfield Street, London, W.1.

Planning Engineers required by Hunting Percival Aircraft Limited. Experience in manufacture, installation and production planning of metal airframe components, and/or A.M. modifications procedure essential. Good welfare facilities, including staff pension scheme. Applications, stating age, salary required, and full details of experience to: Personnel Manager, Hunting Percival Aircraft Limited, Luton Airport, Bedfordshire.

Toolroom Superintendent. The Mettoy Company Limited, Swansea, seek the services of a suitable qualified man for the post of Toolroom Superintendent. First-hand experience of combination and progression press tools is essential and knowledge of plastic moulds and production methods desirable. Applications should be addressed to: The Personnel Manager, and marked "Confidential".

Production Development Engineers required for developing new methods and processes for automobile components. Experience of planning and layout of machine shop essential. Send details of age, experience and salary required to: Box No. 1127, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant Works Manager required on mechanised vehicle work for engineering Works in Eastern Counties near coast. Candidate should have obtained Higher National Certificate, had good practical experience, with organising ability. Aged 35 - 45. Applications, stating qualifications and experience to: Box No. 1128, I.Prod.E., 10 Chesterfield Street, London, W.1.

Methods Engineer required by toolmakers specialising in moulds for the plastics industry. Versatile man able to introduce new ideas into the toolroom. Pension scheme and good working conditions. Applications to: Box No. 222, R. Anderson & Co., 14 William IV Street, London, W.C.2.

Engineers, Chemists and Draughtsmen. Commonwealth of Australia, Department of Defence Production. Vacancies exist for engineers, chemists and draughtsmen on the staff of the above Department at salaries ranging from

£974 (Aust.) to £1,898 (Aust.) for engineers and chemists and £890 (Aust.) to £1,394 (Aust.) for draughtsmen, depending upon the responsibilities of the position and the qualifications and experience of the applicant. The Department has establishments located in the States of Victoria and New South Wales, which are engaged in the production of aircraft, ordnance, gun mountings, ammunition, bombs, fuzes, small arms, marine engines, explosives (manufacture and filling) and other Service requirements. These establishments are equipped with modern plant and are producing equipment for the Armed Services to the latest designs. Positions are available in the production, inspection, development, maintenance, planning and drafting departments. Professional qualifications desired are:- **Engineers** — (mechanical, chemical, electrical and production). Academic training qualifying for corporate membership of the appropriate engineering Institution. **Chemists.** Academic training (with chemistry as a major subject) qualifying for Associateship of the Royal Institute of Chemistry. **Draughtsmen.** Completion of a course in draughtsmanship. **Experience.** For appointment to positions in the higher salary ranges applicants should have had good experience in the practice of their profession — preferably in production. **Conditions of Engagement.** Suitable applicants will be offered permanent appointment to established positions within the Department. Vacancies also exist in the temporary establishment but the tenure of employment is not limited. **Fares.** First-class boat fares (if first-class berths available) of the appointee and dependants will be paid by the Commonwealth ; subject to the appointee entering into a bond to remain in the employment of the Commonwealth for a period of not less than three years from date of commencing duty in Australia. Further particulars and application forms may be obtained from: The Senior Representative (AP.30), Department of Defence Production, Australia House, Strand, London, W.C.2. The closing date for applications will be 23rd July, 1955, and interviews will be held at an early date. All applications will be acknowledged.

Executive Trainee — Production. A leading company in the pharmaceutical industry with a lively record of progress and development has an opening for a highly intelligent young man to enter the production side of the business. The man we look for will have a "mechanical" aptitude (some engineering training would help) and some background allied to production planning, work study, method development and materials appraisal. Every help and encouragement will be given to the successful applicant to build himself into the organisation and the position, which will be adequately remunerated, will lead the right man to the position of Production Manager in twelve to eighteen months. Location, Buckinghamshire. Applications, in confidence, giving fullest details of personal and business history to: Managing Director, Box No. 1129, I.Prod.E., 10 Chesterfield Street, London, W.1.

First-class Tool Fixture Design men. F. Perkins Limited, Peterborough, are seeking first-class tool fixture design men to take part in new expansion programme for the quantity production of i.c. engines. These are permanent and attractive openings for both experienced designers and young men seeking large scale production experience. Preferred qualifications: full works training, preferably in the automobile industry, design or practical experience of special purpose machine tools or auxiliary equipment, Ordinary National Certificate standard of education (technical). Each and every applicant irrespective of age, will receive careful examination, be treated in strictest confidence and receive a reply. Applications should be addressed to: The Personnel Manager.

Work Study Engineer required to assist in introduction of work study into large engineering works in the Slough area. Applicants, age 25 - 35, should have some experience of method study and work measurement techniques. Experience of press work an added advantage. The post is a staff appointment and holds excellent prospects for advancement. Pension and profit-sharing schemes after 12 months. Write in confidence, stating age, education, experience and present salary to: Personnel Manager, Box No. 1130, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant Chief Ratefixer required by important Company in Home County engaged on radar and electronic engineering projects. Experience of time study, motion economy, compilation of synthetics and application of incentives to indirect workers essential. A fundamental knowledge of factory organisation round batch or jobbing production, especially in this branch of industry would be an advantage. Please write in confidence and giving full particulars to: Box No. 1131, I.Prod.E., 10 Chesterfield Street, London, W.1.

Time Study Engineers. Rotax Limited, Aircraft Electrical Engineers, require Time Study Engineers. Men experienced in ratefixing and work study will be considered. The positions are superannuated and give ample opportunity for promotion. Successful applicants will have the opportunity of renting a modern house or flat in the New Town and preference will be given to candidates who are on an approved housing list in the Greater London area. Applications should be made in writing, giving full details of qualifications and experience to: The Personnel Manager, Rotax Limited, Maylands Avenue, Hemel Hempstead, Herts.

Planning Manager required by manufacturers to take charge of production planning and progressing at the West London factory. Previous experience of production planning on a large and varied scale essential. The position, a senior one in the organisation — is permanent and pensionable and offers scope for initiative and drive. Salary according to qualifications and experience but not less than £1,100 per annum. Applicants should write, giving details of education, age, experience and salaries earned to: Box No. 1132, I.Prod.E., 10 Chesterfield Street, London, W.1.

Designers and Research Engineers are required for development work on new hydraulic machines, automatic controls and servo mechanisms. The work offers scope to mechanical and electrical engineers with a gift for invention and experimentation. In replying give full details of experience and salary expected. Degree or H.N.C. with endorsements is necessary. Applications should be addressed to: Personnel Officer, Vickers-Armstrongs Limited, Elswick Works, Newcastle-upon-Tyne 4.

Chief Inspector, A.I.D. and A.R.B. required for expanding light engineering works, West London, Greenford district. Applicants should have sound training and be qualified technically as mechanical engineers with administrative background. A knowledge of personal relationships is essential. A permanent position and pension scheme. Applicants should give details of experience and qualifications. Age about 40. Box No. 1133, I.Prod.E., 10 Chesterfield Street, London, W.1.

Senior Production Engineer. A progressive engineering company in the South of London area engaged in manufacture of machinery for the plastics industry requires a Senior Production Engineer. The successful candidate will ultimately take full responsibility under the Works Director for all aspects of manufacture including jig and tool design, planning and ratefixing, machining and assembly. Minimum qualifications are H.N.C.; at least five years Senior Works administrative experience including control of workshops; sound production engineering training and experience. A University degree would be a desirable additional qualification and candidates should be preferably in the 32 - 50 age group. The salary will be commensurate with the responsibilities of this important post and some housing assistance may be given if required. Apply in strict confidence for application form to: Box No. 1134, I.Prod.E., 10 Chesterfield Street, London, W.1.

Mechanical Engineer (or Physicist), with University engineering degree, required for senior position in research and development of Company in light precision engineering in Central London. Age about 34 - 44: research experience,

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knowledge of patents and languages desirable. Starting salary £1,200 to £2,000 per annum according to qualifications. Non-contributory pension scheme available. Box No. 1135, I.Prod.E., 10 Chesterfield Street, London, W.1.

Engineer. Automobile manufacturing group have vacancy in London export headquarters for an engineer with the following qualifications:- (1) Secondary or public school education. (2) H.N.C., or B.Sc. (3) Apprenticeship with large motor manufacturers. (4) Experience in—factory layouts, production planning, equipment design and purchase, in the motor industry. (5) Knowledge of the commercial aspects of vehicle manufacture and assembly. (6) Age between 30 and 40. (7) Willingness to travel overseas. The appointment is pensionable and offers scope to capable engineer for considerable advancement. Applications, which will be treated in strictest confidence, should include the fullest details and a photograph (returnable), to be addressed to: The Secretary, Ref. T.D., Rootes Limited, Devonshire House, Piccadilly, London, W.1.

Time Study and Ratefixing Engineer required by cable works. Age between 25 to 35 years, preferably with experience in a process industry. Salary according to age, qualifications and experience. Pension scheme. Apply in confidence, giving particulars in chronological order to: Works Manager, Southern United Telephone Cables Ltd., Dagenham Dock, Essex.

Production Engineer, required by Midlands Private Company in the sheet metal working machinery industry. Ability to institute effective production planning and control, successfully to meet current and subsequent company developments will ensure the future career of the successful applicant. Men, aged 30 to 40, with previous experience fitting them for this appointment apply, detailing age, experience, qualifications and salary requirements to: Box No. 1136, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Production Engineer required by well-known electronic engineering company. Must have had considerable experience of mechanical design, process planning, tool design and estimating in connection with electronic equipment. Chartered mechanical or electrical engineer preferred but not essential. This is a responsible position and a commensurate salary will be paid to the successful applicant. Write giving full details of experience and present salary to: Personnel Officer, Airmec Limited, High Wycombe, Bucks.

Estimating Engineer required in expanding organisation. Applicants should be between 35 - 40 years of age, have a H.N.C. in mechanical or production engineering, and preferably have experience of the telephone or electronic industry. Apply: Personnel Officer, Airmec Limited, High Wycombe, Bucks.

Senior Work Study Engineer. Imperial Chemical Industries Limited, Plastics Division, has a vacancy for a senior Work Study Engineer. Applicants should have had considerable practical experience of method and time study techniques, wage incentive schemes, and labour and cost control, as applied to both direct and indirect labour. The job calls for initiative and will entail travelling. Possession of an engineering degree or similar qualification would be an advantage. Applications, giving age and full details of education, qualifications, experience and present salary, should be sent to: The Staff Manager, Imperial Chemical Industries Limited, Plastics Division, Black Fan Road, Welwyn Garden City, Herts.

Time and Motion Study Engineer, age 30 to 42, wanted by well-known firm of industrial consultants. Experience of all aspects of time and motion study work in a wide range of industries, as well as knowledge of ratefixing, essential. Salary according to qualifications and experience. Write: Box No. 1137, I.Prod.E., 10 Chesterfield Street, London, W.1.

Toolmaking and Precision Engineering. Highly reputable and very well equipped trade toolmakers, situated 20 miles West of London and employing 60, invite applications for the following key positions:- **Production Manager,** to carry out estimating and planning and be responsible for production on the office side. **Works Superintendent,** to supervise and be responsible for production on the works side. **Chief Inspector,** working and responsible for quality and A.I.D., etc. procedures (previous inspection experience not essential). These positions require energetic men of top ability and will carry ample remuneration. There are no age restrictions and any prior holiday arrangements would be met. Please write full details with salary expected to: Box No. 1138, I.Prod.E., 10 Chesterfield Street, London, W.1.

Works Manager wanted by well equipped engineering Works with foundry. 700 employees (public company). Experience in mass production, quality, cost consciousness and dynamic approach imperative. Engineering degree desirable. Excellent prospects of lifetime position for right type of applicant used to and capable of accepting higher executive responsibility. Pension Scheme. Apply with full details to: Box No. 1139, I.Prod.E., 10 Chesterfield Street, London, W.1.

Qualified Engineers. Creative and interesting jobs of a professional character exist in a leading firm of Management Consultants. Men of mature personality and resourceful outlook are sought, who must be qualified engineers and who have had executive experience. Starting remuneration, which is in the four figure range, increases substantially after a training period appropriate to the individual. Non-contributory superannuation life assurance and a profit-sharing scheme are included in the remuneration arrangements, which also take full cognizance of initiative and character. Applicants should be over 27 and under 40 years of age. Write, with full particulars to: Box No. 1140, I.Prod.E., 10 Chesterfield Street, London, W.1.

Machine Tool Designer conversant with design of cam operated metal cutting machines. Applicant must be capable of designing complete machines from general specification of capacities and description of mechanism to be utilised. Excellent opportunity with first-class well-known Company. All applications will be treated with strictest confidence. Please apply, stating full experience, age and salary expected to: Box No. 1113, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Planning Engineer required for medium size works in West London area. Should have knowledge of modern machine shop practice and methods. Applicant will be required to break down programmes to component part and sub assembly requirements — be able to assess plant capacities — fix suitable economic batch quantities and set up machine loading system. Age 30 to 40. Apply, stating education, qualifications, posts held and present salary to: Box No. 1141, I.Prod.E., 10 Chesterfield Street, London, W.1.

EDUCATIONAL APPOINTMENTS

Northampton Polytechnic, London, E.C.1.
Lecturers for full-time, permanent, pensionable staff required to instruct students in:- (a) Instrument Engineering. (b) Production Engineering. Candidates should have H.N.C. or equivalent and some industrial experience. Salary on Burnham London Scale according to qualifications and experience, commencing at £486 per annum, plus up to £216 for industrial service after the age of 21, plus £60 for degree qualification. Scale rises to at least £773. Excellent opportunity for entering the technical teaching profession and for promotion to upper scales rising to over £1,100 a year. Particulars and form of application from Secretary.

Southall Technical College, Beaconsfield Road, Southall, Middlesex.
(1) Two Assistants (Grade B) in the Mechanical Engineering Department. (2) Two Assistants (Grade B)

in the Mechanical Engineering Department to teach Engineering Workshop Practice and allied subjects. Applications are invited for the following posts:- (1) Two Assistants (Grade B) in the Mechanical Engineering Department to teach engineering subjects up to the Ordinary National Certificate standard. Preference will be given to those able to offer the subject of workshop technology. and having a knowledge of machine tools and metrology. (2) Two Assistants (Grade B) in the Mechanical Engineering Department to teach engineering workshop practice and allied subjects in machine shop engineering courses leading to the Intermediate and Final Examinations of the City and Guilds of London Institute. Preference for one post will be given to applicants with a good knowledge of press tool work, whilst in the other post, experience in aircraft work would be an added qualification. In posts (1), applicants should have a degree or equivalent qualification, whilst for those in (2), sound technological qualifications are essential. In all these posts, applicants should have good industrial and preferably some teaching experience. Duties to commence 1st September, 1955. Salaries in accordance with the Burnham (Technical) Report, 1955, plus London allowance. Grade B £525 by £25 to £820 (men). Application forms (stamped addressed foolscap envelope) from the Principal, to whom completed forms should be returned within fourteen days of the appearance of this advertisement.

Dudley and Staffordshire Technical College.
Applications are invited for the appointment of a Grade B Assistant Lecturer in Production Engineering. Applicants must have had adequate workshop experience and must hold a Higher National Certificate in Production Engineering or in Mechanical Engineering with Production Engineering bias. Duties will begin on 1st September, 1955. Salary — Burnham Scale, £525 x £25 — £820 with increments for training and experience. Application forms and further particulars may be obtained from the Principal, Dudley and Staffordshire Technical College, Dudley, to whom the completed forms should be returned as soon as possible.

Paddington Technical College.
Lecturer in Machine Shop Engineering. As soon as possible Lecturer in Machine Shop Engineering, to teach to Final City and Guilds Standard in Machine Shop Engineering, also responsible for certain trades courses in the College. Burnham salary scales £965 x £25 — £1,065, plus London allowance. Application forms from the Secretary at College, Saltram Crescent, London W.9, to be returned by 23rd July, 1955.

Municipal Technical College, Hopwood Lane, Halifax.
Full-time teachers in the Department of Engineering. Applications are invited for the following posts of full-time teachers in the Department of Engineering from 1st September, 1955, or as soon as possible thereafter. Grade A Assistant to teach mechanical engineering subjects to Ordinary National Certificate and Intermediate City and Guilds level. Ability to take workshop practice classes is very desirable. Candidates should hold a Higher National Certificate or equivalent qualification. Grade B Assistant able to teach Strength of Materials and/or Theory of Machines at Higher National Certificate level. Candidates should hold an Engineering Degree or equivalent qualification. Industrial experience is essential and previous teaching to H.N.C. level is desirable. Salary — Burnham Scale, Grade A £450 x £18—£725, Grade B £525 x £25—£820. Approved industrial experience, National Service, graduate and training allowances will be taken into account in fixing initial salary. Further particulars may be obtained from the Principal, Municipal Technical College, Hopwood Lane, Halifax, to whom applications should be returned as soon as possible.

Loughborough College of Technology — Department of Industrial Engineering.
Appointment of Lecturer in Primary Forming Processes. Applications are invited for the post of Lecturer in Primary Forming Processes, comprising such subjects as press and sheet metalwork, welding processes, and foundry technology. The Lecturer appointed must be capable of dealing with these subjects to an advanced stage. He should have had considerable industrial experience and, preferably, hold qualifications in production engineering and metallurgy. Teaching experience will be an advantage. Salary will be paid according to the scale for Lecturers of the Burnham Committee Award, 1954, namely, £965 x £25 — £1,065. Further particulars and application forms can be obtained from The Registrar.

Wolverhampton and Staffordshire Technical College.
Grade B Assistant in Production Engineering. Applications invited for the post of Grade B Assistant in Production Engineering to teach subjects up to the standard of Higher National Certificate in Production Engineering and Final Examination of City and Guilds Machine Shop Engineering. A good industrial background is essential and teaching experience desirable. A practical knowledge of machine tool operation will be an added advantage. Salary in accordance with Burnham Technical Report. Further particulars and application form from, G. W. R. Lines, Clerk to the Joint Education Committee, Education Offices, North Street, Wolverhampton. (Stamped addressed envelope.)